Bellflower Solar Project Pre-Construction Sound Report

Prepared for:
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Abbreviations

AC	Alternating Current
dB	Decibel
dB(Z) or dBZ	Decibel (unweighted)
dB(A) or dBA	Decibel (A-weighted)
dB(C) or dbC	Decibel (C-weighted)
DC	Direct Current
GA	Ground Attenuation
Hz	Hertz
L_{eq}	Equivalent continuous sound level
MW	Megawatt
NSA	Noise sensitive area
Project	Bellflower Solar Project
PV	Photovoltaic
SLM	Sound Level Meter

1.0 Project Description

Lightsource Renewable Energy North America (Lightsource) is proposing to develop and construct the Bellflower Solar Project (the "Project") near New Castle, Indiana. The Project is located across approximately 1,305 acres in Henry and Rush Counties (Figure 1). The Project includes the development of an approximately 152.5 megawatt (MW) alternating current (AC) utility scale solar energy generation facility. In addition to photovoltaic modules, the Project will also include single access trackers, inverters, an electrical collection system, access roads, a substation, and perimeter security fencing. Lightsource retained the services of Stantec Consulting Services Inc. (Stantec) to conduct a pre-construction ambient sound survey and assessment for the Project.

The solar arrays will be constructed on multiple non-contiguous agricultural parcels roughly bounded by South County Road 25 West to the east, South County Road 225 West to the west, US-40 to the north, and County Road 1100 North to the south. There is a scattering of homes and farms located along the Project boundary. The electricity generated by the solar facility will be routed to an electrical substation located on South County Road 125 West. Much of the area for the Project is agricultural land with low density residential development.

The two sources of sound emissions from the operational Project are the inverters and the substation transformer. The solar panels produce direct current (DC) voltage which must be changed to AC voltage through a series of inverters. Solar energy facilities operate by converting solar radiation into electricity, meaning the Project will only produce electricity between sunrise and sunset. After sunset, the site no longer receives solar radiation and the inverters will not operate and produce sound. Approximately 49 inverters will be installed throughout the Project area. Manufacturer's specifications for the inverter are provided in Appendix A. The analysis performed for this report assumed the use of the Power Electronics' HEM unit. Per the manufacturer's specifications, the maximum sound level from each inverter skid is 79 decibels (A-weighted) (dBA) at one meter (approximately three feet).

The Project will include a step-up transformer located within the substation footprint. The transformer is generally expected to run during the times that the solar array will be generating power (daylight hours). The substation transformer will be energized during the nighttime but will not produce sound. The sound specifications of the substation transformer indicate a sound level of approximately 84dBA at one meter (approximately three feet).[1]

2.0 Sound Level Requirement

Sound is caused by vibrations that generate waves of minute pressure fluctuations in the surrounding air. Sound levels are typically measured using a logarithmic decibel (dB) scale. Human hearing varies in sensitivity for different sound frequencies. The ear is most sensitive to sound frequencies between 800 and 8,000 hertz (Hz) and is least sensitive to sound frequencies below 400 Hz or above 12,500 Hz. Consequently, several different frequency weighting schemes have been used to approximate the way the human ear responds to sound levels. The decibel (A-

[1] National Electric Manufacturers Association, *NEMA TR 1-2013 Transformers, Step Voltage Regulators and Reactors*

weighted) or dBA scale is the most widely used for regulatory requirements, such as the Occupational Safety and Health Administration as it discriminates against low frequencies, like the response of the human ear. The decibel (C-weighted) sound level (dBC) does not discriminate against low frequencies. Unweighted sound levels are generally reported as dB or dBZ.

For context, a soft whisper has a sound level of approximately 30 dBA, while a normal conversation is approximately 60 dBA. Common household appliances range in sound pressure levels from 40 dBA (refrigerator hum) to 60 dBA (air conditioner)[2].

State and local sound regulations were reviewed, however, no current regulations directly applicable to noise of a solar facility were identified for Henry or Rush County or within the state of Indiana.

3.0 Measurement Methodology

Aerial imagery, land ownership records, and field surveys were utilized to identify noise sensitive areas (NSA), including residences, and other sensitive areas located near the Project to analyze ambient sound levels. Based upon the identified NSAs, Stantec identified eight baseline sound monitoring locations for analysis. Stantec selected monitoring locations that represent the overall Project layout, with locations near residences with potential solar arrays in multiple directions and in proximity to the substation. Consideration was also made to represent residences that may be impacted by existing vehicle traffic on nearby roadways. Figure 1 displays the Project components relative to the monitoring site locations.

Ambient sound measurements were made at noise monitoring areas BF-ML-1, BF-ML-2, BF-ML-3, BF-ML-4, BF-ML-5, BF-ML-6, BF-ML-7 and BF-ML-8. One 20-minute sound level measurement was recorded at each of the eight locations during daytime hours, while a second evening measurement (between the hours of 8 pm and 10 pm) was also taken at BF-ML-1 and BF-ML-7. BF-ML-1 is located near the proposed substation, which has the possibility of operating at night. A second measurement was taken at BF-ML-7 due to its proximity to US-40. Because of traffic patterns on major roadways where traffic and correspondingly noise is greatest during the day, it was expected that there would be a large difference between the daytime sound level measurement at BF-ML-7 and the nighttime measurement. Therefore, two measurements were collected at that monitoring location in an effort to capture both conditions.

Stantec collected the day and night sound samples on August 19, 2020 and August 20, 2020. A Type 1 Quest Technologies SoundPro DL Sound Level Meter (SLM) was used to measure the octave band and broadband ambient sound pressure levels in the selected locations. The meter was set to flat scale, slow response with a three-dB exchange rate for the octave band readings, with concurrent Leq measurements made in A-scale, slow response at a three-dB exchange rate. The following procedures were used during the noise measurements at the locations:

- Calibrate SLM;

[2] Centers for Disease Control and Prevention. 2019. What Noises Cause Hearing Loss? https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html

- Fit SLM with windscreen and mount on a tripod with the microphone oriented toward the proposed substation or solar array at a height of approximately four feet above the ground surface;
- Program the SLM to acquire at least 20 one-minute scans of ambient sound;
- Acquire sample, which is digitally recorded in the SLM's integral data logger by downloading data to a spreadsheet using Larson Davis software.

4.0 Monitoring Results and Observations

Ambient sound level monitoring results are reported as energy-equivalent (L_{eq}) sound levels, where the L_{eq} is the level of steady sound with the same total energy as the time-varying sound energy averaged over a given period. This number is an average used to account for the louder and quieter periods during a recorded period. Tables 4.1 and 4.2 summarize the results of the ambient sound measurement readings near the Project inverters and substation. Ambient sound levels during the daytime varied across the monitoring locations, ranging from a L_{eq} of 41.6 to 52.1 dBA.

In assessing ambient sound levels, it is also informative to understand the fluctuations in the sound levels rather than just the average (L_{eq}). This is reported as percentile levels (L_n), where L_n is the sound level exceeded for n% of the measurements. For this Project the L_{10}, L_{50}, and L_{90} values are reported for each monitoring station. For context, this means that statistically, the sound level at BF-ML 1 exceeded 45.3 dBA 10% of the time, while a sound level of 35.7 dBA was exceeded 90% of the time during the monitoring period.

TABLE 4.1 AMBIENT SOUND PRESSURE LEVEL MEASUREMENTS SUMMARY AT DAYTIME MONITORING LOCATIONS 1 TO 8

Sound Levels	Monitoring Locations (dBA)							
	BF-ML 1	BF-ML 2	BF-ML 3	BF-ML 4	BF-ML 5	BF-ML 6	BF-ML 7	BF-ML 8
L_{eq}	46.6	41.6	49.3	51.4	50.9	46.3	49.8	52.1
L_{10}	45.3	43.1	47.7	48.1	44.4	46.6	49.6	47.3
L_{50}	39.5	41.2	44.2	40.7	40.9	44.2	47.4	44.8
L_{90}	35.7	39.4	40.8	36.9	39.2	41.2	46.2	44.3

The predominant sound sources at the sites were distant vehicle traffic and occasional passing cars. Additional sounds that were recorded included toads and frogs, corn rustling in the wind, birds chirping and insects.

TABLE 4.2 AMBIENT SOUND PRESSURE LEVEL MEASUREMENTS SUMMARY AT NIGHTTIME MONITORING LOCATIONS 1 AND 7

Sound Levels	Monitoring Locations (dBA)	
	BF-ML 1	BF-ML 7
L_{eq}	42.5	49.9
L_{10}	46.3	53.6
L_{50}	40.7	44.2
L_{90}	36.2	40.2

The predominant sound sources at the sites at nighttime were distant vehicle traffic, and occasional passing cars. Additional sounds that were recorded included toads and frogs, a dog barking and insects.

5.0 Assessment of Sound Impacts during Operation

Approximately 49 inverters will be installed within the Project area. The nearest residence to an inverter is approximately 545 feet. Per the manufacturer's specifications, the maximum sound pressure level from each inverter is less than 79 dBA at a distance of one meter (approximately three feet). For this analysis a sound power level of 87.1 dBA at the source was utilized. A tonal penalty of 5 dBA was added to each octave band resulting in an overall sound pressure level of 92.1 dBA for each inverter, to be conservative. The inverters will only operate when the sun is shining, therefore most of the operation will occur during daytime hours.

A sound analysis was completed for the invertor skids operating at full load. A contour map showing the overall expected sound levels from the total solar array with all inverters operating is provided as Figure 2. Estimated sound levels from the proposed facility in dBA at various distances from an inverter is shown in Table 5.1.

TABLE 5.1 ESTIMATED SOUND LEVEL DUE TO BELLFLOWER SOLAR PROJECT INVERTERS

Source	Noise Source Description	Sound Pressure Level in dBA per Octave-Band Frequency								L_{eq} (dBA)
		63	125	250	500	1000	2000	4000	8000	
A	Inverter Sound Power Level	69	76	79	82	82	79	74	65	87
	Inverter Sound Pressure Level w/ 5 db penalty	74	81	84	87	87	84	79	70	92
	Sound Level Contribution Solar Panel Inverters									
	@ 50 feet	41	48	52	54	54	51	46	36	60
	@ 100 feet	35	42	46	48	48	45	40	28	54
	@ 300 feet	26	33	36	38	38	35	28	13	44
	@400 feet	23	30	33	36	36	32	25	8	41
	@Nearest NSA - 545 feet	21	28	31	33	33	29	21	1	38
	@ 700 feet	18	25	28	31	30	26	18	0	36
	@ 1000 feet	15	22	25	28	27	22	12	0	33
	@ 2000 feet	9	16	19	21	20	14	0	0	26

The receptor expected to receive the most increase in sound due to operation of the Project is located approximately 545 feet from an inverter. The maximum sound level that would be expected at the outside wall of this receptor due to Project operation would be approximately 41.4 dBA. The actual impact will be less, as a 5-dBA tonal penalty is included to create a worst-case situation. The projected values are at or very near the background ambient sound levels detailed in the Section 5.0 and as indicated in Table 5.2, except during the quietest periods represented by the L_{90} values.

The data above was utilized to determine the impact of the inverter sources on the existing environment. Table 5.2 presents the expected changes to existing sound levels for L_{eq}, L_{10}, L_{50}, and L_{90}, in dBA at the closest residence, using the background monitoring data for sample point BF-ML-2.

TABLE 5.2 ESTIMATED MAXIMUM SOUND IMPACT CHANGES DUE TO INVERTERS[3]

Measured Sound Levels at BF-ML-2 (dBA)

Sound Levels	dBA Day
L_{eq}	42
L_{10}	43
L_{50}	41
L_{90}	39

Expected Sound Levels at NSA with Inverter Operating

Sound Levels	dBA Day
L_{eq}	44
L_{10}	45
L_{50}	44
L_{90}	43

Inverters will not operate during nighttime hours

Expected Change in Sound Levels in dBA

Sound Levels	dBA Day
L_{eq}	3
L_{10}	2
L_{50}	3
L_{90}	4

[3] Changes shown in the bottom tables may not match the results in the top two tables due to rounding significant figures.

A sound analysis was completed for the transformer to determine the maximum sound level that would be indicated at the nearest NSA. The substation transformer is estimated to have a sound level of approximately 84 dBA at one meter (approximately three feet). The substation will be set back from the nearest residence by approximately 866 feet. An analysis of the impacts from the transformer is provided in Appendix B and contour a map showing the overall expected sound levels from the project is provided as Figures 2. Estimated sound levels from the proposed facility in dBA at various distances from a substation are shown in Table 5.3.

TABLE 5.3 ESTIMATED SOUND LEVEL DUE TO BELLFLOWER SOLAR PROJECT SUBSTATION TRANSFORMER

Source	Noise Source Description	Sound Pressure Level in dB per Octave-Band Frequency								L_{eq} (dBA)
		63	125	250	500	1000	2000	4000	8000	
B	Transformer	43.6	65.8	75.8	86.6	87	84.4	79	67.8	91
	Transformer w/ 5 dB tonal penalty	48.6	70.8	80.8	91.6	92	89.4	84	72.8	96
	Sound Level Contribution Substation									
	@ 250 feet	3	25	35	46	46	43	36	20	50
	@ 350 feet	0	22	32	43	43	40	33	14	46
	@ 500 feet	0	19	29	40	40	36	28	7	43
	@ Nearest NSA - 866 feet	0	14	24	35	34	31	21	0	38
	@ 1000 feet	0	13	23	33	33	29	18	0	36
	@ 3000 feet	0	3	13	22	21	14	0	0	24

The maximum sound level from sound emitted by the substation transformer at the outside wall of the nearest NSA, which is approximately 866 feet from the transformer, would be 38.0 dBA. This maximum sound value from the substation at all residences is also at or very near the background ambient sound levels detailed in the Section 4.0 and detailed in Table 5.4 below.

The data above was utilized to determine the impact of the Project substation transformer on the existing environment. Table 5.4 presents the expected changes to existing sound levels for L_{eq}, L_{10}, L_{50}, and L_{90}, in dBA at the nearest residence, using the background monitoring data for sample point BF-ML-1.

TABLE 5.4 ESTIMATED MAXIMUM SOUND IMPACT CHANGES DUE TO TRANSFORMER[4]

Measured Sound Levels at BF-ML-1 (dBA)

Sound Levels	dBA	
	Day	Night
L_{eq}	47	43
L_{10}	45	46
L_{50}	40	41
L_{90}	36	36

Expected Sound Levels at Nearest NSA with Substation Transformer Operating

Sound Levels	dBA	
	Day	Night
L_{eq}	47	43
L_{10}	45	46
L_{50}	40	41
L_{90}	37	38

Expected Change in Sound Levels in dBA

Sound Levels	dBA	
	Day	Night
L_{eq}	0	0
L_{10}	0	0
L_{50}	1	1
L_{90}	2	1

Table 5.4 indicates that the sound levels will not be discernable at the residences surrounding the substation transformer.

To further substantiate the calculations shown above, computer modeling of the Project was completed. Sound contours were calculated using the Decibel Module of WindPro Modelling software by EMD International, which utilizes conservative ISO 9613-2 algorithms to estimate sound propagation and atmospheric absorption. The parameters and assumptions made in developing the estimates include the following:

- all inverters and substation are operating;
- substation sound power level was conservatively estimated at 96.3 dBA and an inverter sound power level of 92.1 dBA was used, including an added 5-db penalty;

[4] Changes shown in the bottom tables may not match the results in the top two tables due to rounding significant figures.

- ground attenuation of 0.5 (on a scale of 0.0 representing hard ground to 1.0 representing porous ground) was modelled, as this is conservatively representative of the surrounding environment;
- meteorological conditions were conducive to sound propagation (10 degrees Celsius and 70 percent relative humidity);
- receptors were represented as a center point on the residence (a total of 397 receptors were identified in the model);
- topography (elevations) were considered and estimated using USGS National Elevation Data.

The sound contour map generated by the modeling is presented in Figure 2. Results of the model analysis are included in Appendix B. The maximum modeled sound impact from the solar array at any residence is 41.4 dBA with a ground attenuation of 0.5. These results substantiate the information presented earlier in this section (Table 5.1 and 5.3).

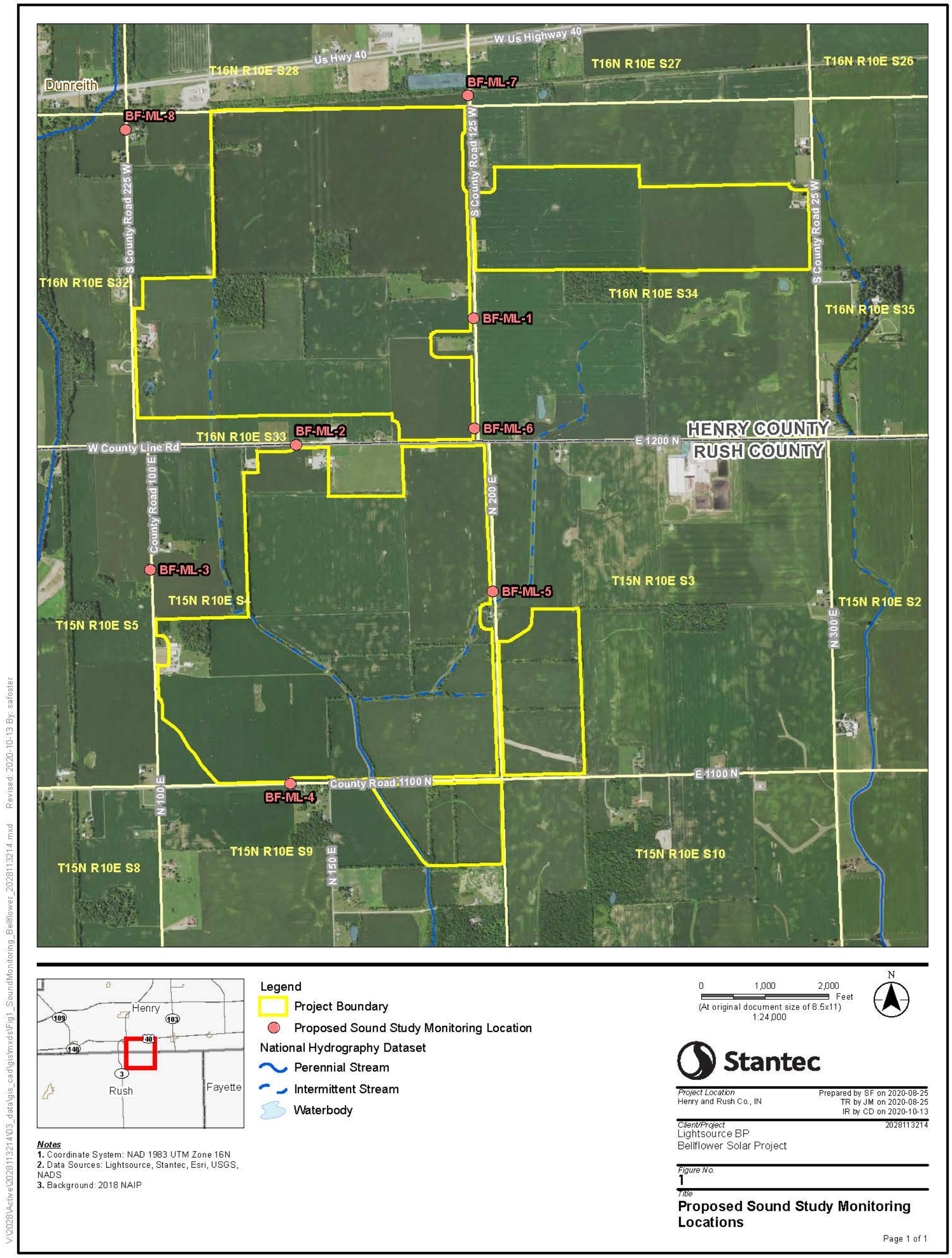
6.0 Summary

On August 19-20, 2020, Stantec completed a pre-construction ambient sound survey of the substation and solar array areas for the Project to quantify the existing acoustical environment. Ambient sound measurements were made at eight noise monitoring locations (BF-ML-1, BF-ML-2, BF-ML-3, BF-ML-4, BF-ML-5, BF-ML-6, BF-ML-7 and BF-ML-8). Stantec considered locations that represent the overall Project layout, with locations near residences with potential solar arrays in multiple directions and in the area of the substation. One short term (20-minute) sound level measurement was conducted at each of the eight locations. One additional sound measurement was taken at BF-ML-1 and BF-ML-7. This additional measurement was taken to represent the sound impacts of the substation at night and to get data that was less impacted by the daytime vehicle traffic on US-40, which is located immediately north of the Project boundary. The day samples were collected by Stantec on Wednesday, August 19th and Thursday, August 20th, 2020. The night samples were collected on Wednesday, August 19th, 2020 by Stantec. Based upon the L_{eq} values, the background sound levels varied from 41.6 to 52.1 dBA among the sample locations and sample periods. The predominant sound source during the sampling was vehicular traffic, along with birds and insects, and rustling corn.

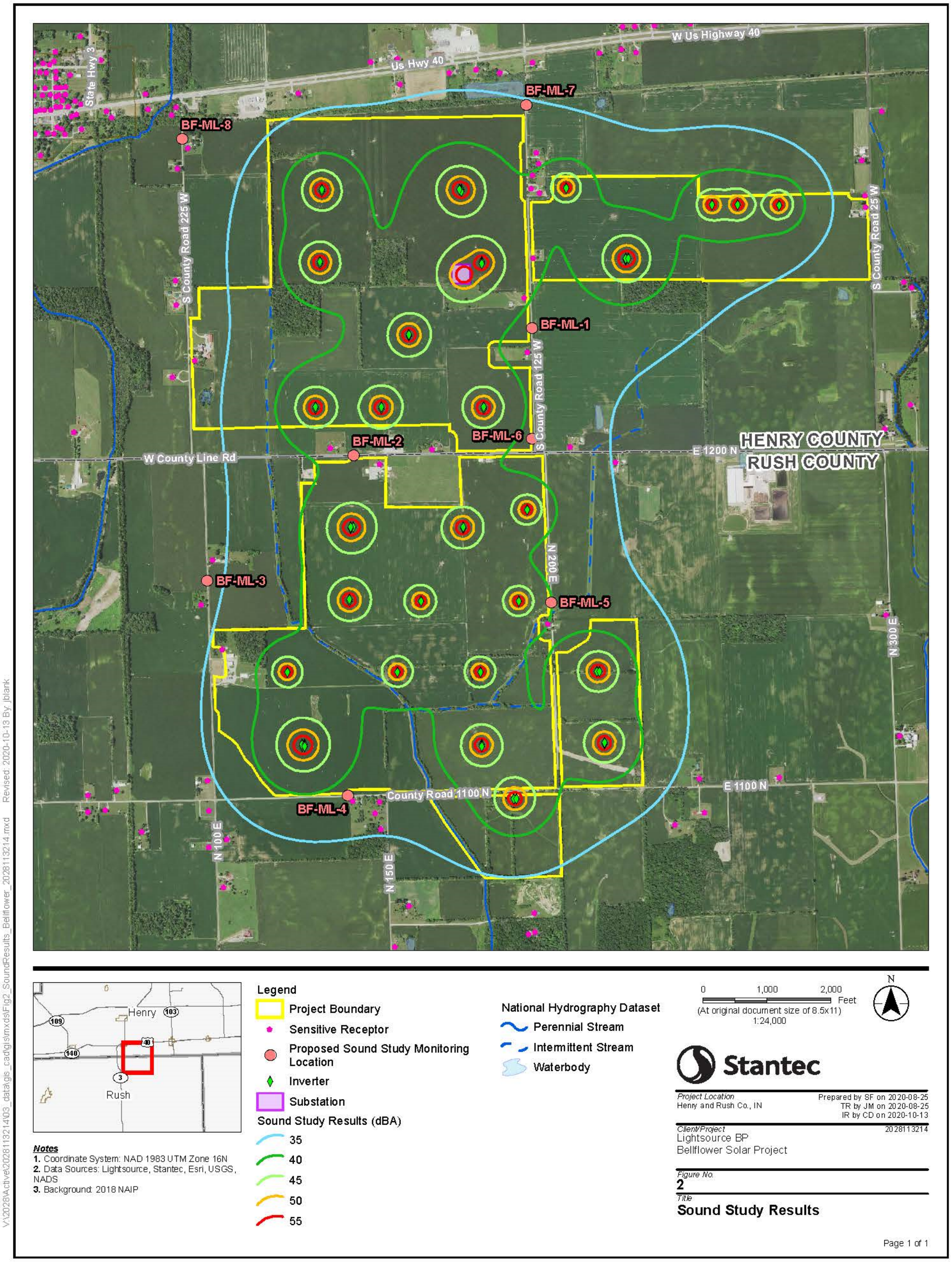
Sound analyses were completed for both an inverter skid and the substation transformer based on information provided by the equipment manufacturers. The maximum sound impact at the nearest residence to a solar inverter was calculated to be 41.4 dBA and a maximum sound impact from the substation transformer was calculated to be 39.6 dBA. This finding was further substantiated by computer modeling of the entire solar array.

Sound resulting from the operation of the solar facility is anticipated to have minimal impact on nearby residences. No additional mitigation measures are required above complying with the equipment specifications used for this analysis.

Figures



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.


W Us Highway 40
Us Hwy 40
State Hwy 3
BF-ML-7
BF-ML-8
S County Road 225 W
S County Road 25 W
BF-ML-1
S County Road 125 W
BF-ML-6
BF-ML-2
W County Line Rd
E 1200 N
HENRY COUNTY
RUSH COUNTY
N 200 E
BF-ML-3
BF-ML-5
N 300 E
E 1100 N
County Road 1100 N
BF-ML-4
N 100 E
N 150 E
Henry
Rush
Legend
Project Boundary
Sensitive Receptor
Proposed Sound Study Monitoring Location
Inverter
Substation
Sound Study Results (dBA)
35
40
45
50
55
National Hydrography Dataset
Perennial Stream
Intermittent Stream
Waterbody
0 1,000 2,000 Feet
(At original document size of 8.5x11)
1:24,000
N
Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: Lightsource, Stantec, Esri, USGS, NADS
3. Background: 2018 NAIP
Stantec
Project Location
Henry and Rush Co., IN
Prepared by SF on 2020-08-25
TR by JM on 2020-08-25
IR by CD on 2020-10-13
Client/Project
2028113214
Lightsource BP
Bellflower Solar Project
Figure No.
2
Title
Sound Study Results
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Appendix A

Acoustic Sound Specifications – Inverters

HEM

UTILITY SCALE MV CENTRAL STRING INVERTER

FRU **FIELD REPLACEABLE UNITS**

OUTDOOR DURABILITY

NEMA 3R / IP54

ICOOL 3

ACTIVE HEATING

3 LEVEL TOPOLOGY

ECON MODE

! **NEW RATINGS**

THE INNOVATIVE MEDIUM VOLTAGE CENTRAL STRING INVERTER

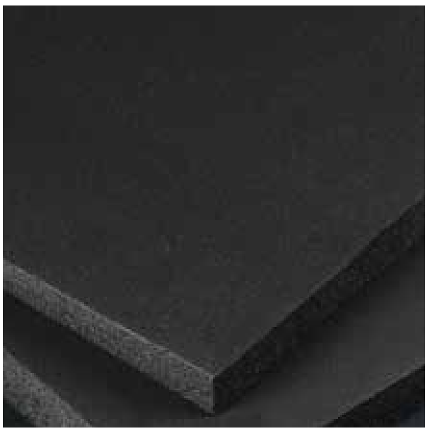
The Power Electronics HEM medium voltage inverter is designed for utility scale solar applications, that require the advantages of a central inverter solution but also the modularity of a string architecture. The HEM can reach up to a nominal power of 3.6MVA, and offers a wide MPPT window. It also has the added advantage of having an integrated medium voltage transformer and switchgear.

Its architecture, composed of six field replaceable units (FRU), is designed to provide the highest availability and optimize yield production. Its use in Utility Scale PV plants provides considerable savings in CAPEX, since having an integrated MV transformer and switchgear reduces the need of additional connections between the LV and MV sides.

Thanks to the Power Electronics iCOOL3 cooling system, the HEM is able to provide IP54 degree of protection with an air cooling system, and as a result reducing OPEX costs.

ROBUST DESIGN

Polymeric Painting



Closed-Cell Insulation

Galvanized Steel | Stainless Steel (Optional)

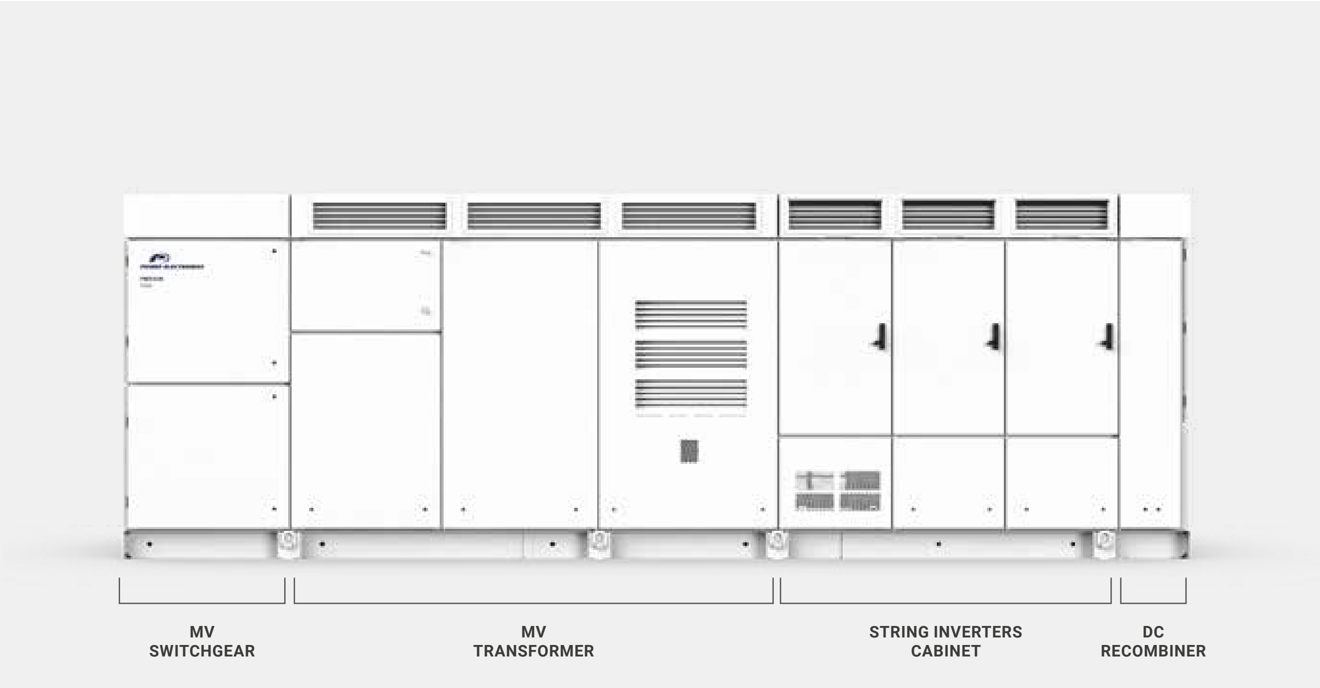
HEM inverter modules have a design life of greater than 30 years of operation in harsh environments and extreme weather conditions. HEM units are tested and ready to withstand conditions from the frozen Siberian tundra to the Californian Death Valley, featuring:

- Totally sealed electronics cabinet protects electronics against dust and moisture.
- Conformal coating on electronic boards shields PCBs from harsh atmospheres.
- Temperature and humidity controlled active heating prevents internal water condensation.
- C4 degree of protection according to ISO 12944. Up to C5-M optional.
- Closed-Cell insulation panel isolates the cabinet from solar heat gains.
- Roof cover designed to dissipate solar radiation, reduce heat build-up and avoid water leakages.
- The solid HEM structure avoids the need of additional external structures.
- Random units selected to pass a Factory Water Tightness Test ensuring product quality.
- NEMA 3R / IP54.

REAL TURN-KEY SOLUTION - EASY TO SERVICE

With the HEM, Power Electronics offers a real turn-key solution, including the MV transformer and switchgear fully assembled and tested at the factory. The HEM is a compact turn-key solution that will reduce site design, installation and connection costs.

By providing full front access the HEM series simplifies the maintenance tasks, reducing the MTTR (and achieving a lower OPEX). The total access allows a fast swap of the FRUs without the need of qualified technical personnel.



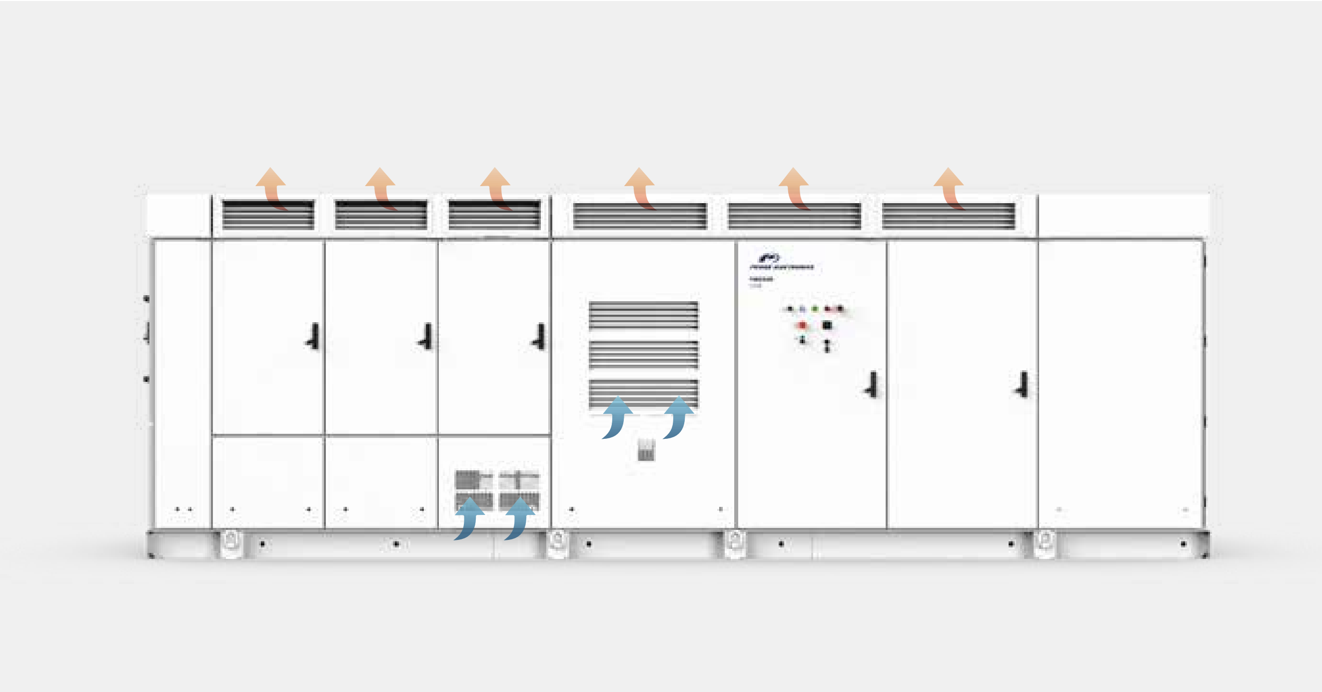
STRING CONCEPT POWER STAGES

The HEM combines the advantages of a central inverter with the modularity of the string inverters. Its power stages are designed to be easily replaceable on the field without the need of advanced technical service personnel, providing a safe, reliable and fast Plug&Play assembly system.

Following the modular philosophy of the Freesun series, the HEM is composed of 6 FRUs (field replaceable units), where all the power stages are physically joined in the DC side and therefore, in the event of a fault, the faulty module is taken off-line and its power is distributed evenly among the remaining functioning FRUs.

INNOVATIVE COOLING SYSTEM

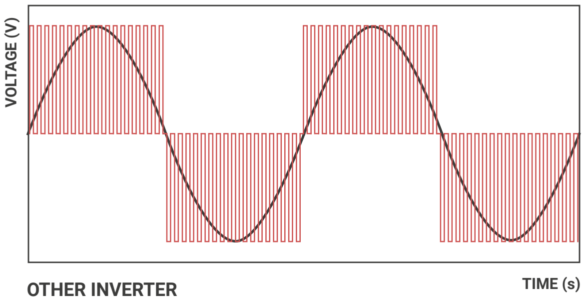
Based on more than 3 years of experience with our MV Variable Speed Drive, the iCOOL3 is the first air-cooling system allowing IP54 degree of protection in an outdoor solar inverter. iCOOL3 delivers a constant stream of clean air to the FRUs and the MV transformer, being the most effective way of reaching up to IP54 degree of protection, without having to maintain cumbersome dust filters or having to use liquid-cooling systems, avoiding the commonly known inconveniences of it (complex maintenance, risk of leaks, higher number of components…), therefore resulting in an OPEX cost reduction.



MULTILEVEL TOPOLOGY

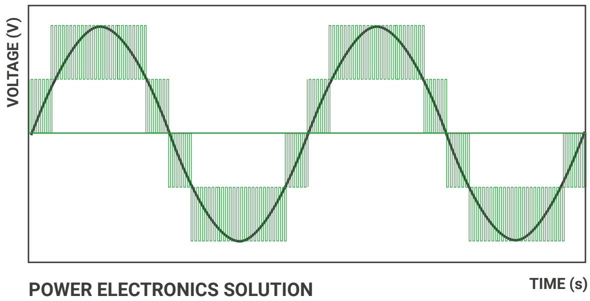
The multilevel IGBT topology is the most efficient approach to manage high DC link voltages and makes the difference in the 1,500 Vdc design. Power Electronics has many years of power design in both inverters and MV drives and the HEM design is the result of our experience with 3 level topologies. The 3 level IGBT topology reduces stage losses, increases inverter efficiency and minimizes total harmonic distortion.

TWO-LEVEL INVERTER



OTHER INVERTER

THREE-LEVEL INVERTER



POWER ELECTRONICS SOLUTION

VAR AT NIGHT

At night, the HEM inverter can shift to reactive power compensation mode. The inverter can respond to an external dynamic signal, a Power Plant Controller command or pre-set reactive power level (kVAr).

ACTIVE HEATING

At night, when the unit is not actively exporting power, the inverter can import a small amount of power to keep the inverter internal ambient temperature above -20°C, without using external resistors.

This autonomous heating system is the most efficient and homogeneous way to prevent condensation, increasing the inverters availability and reducing maintenance. **PATENTED**

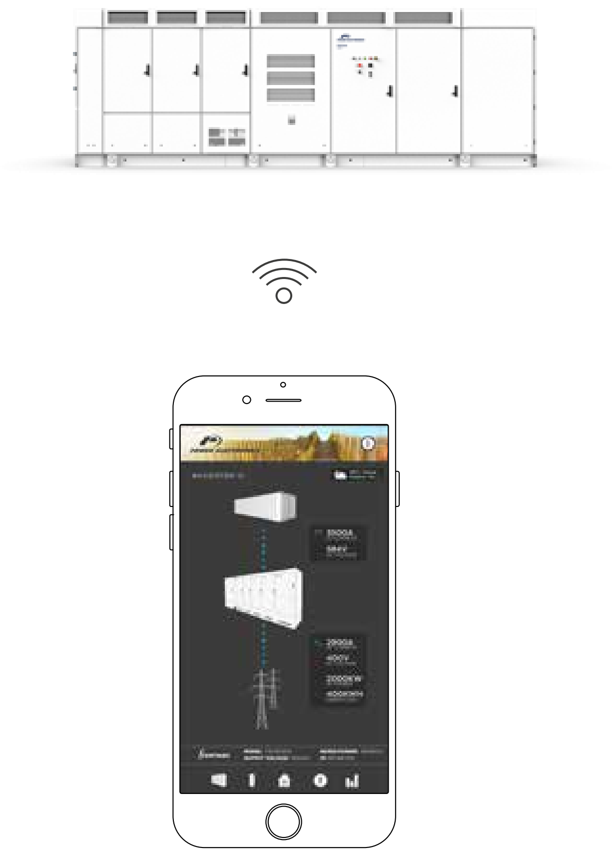
ECON MODE

This innovative control mode allows increasing the efficiency of the MV transformer up to 25%, reducing the power consumption of the plant and therefore providing considerable savings. Available as an optional kit, this feature has a payback time of less than a few years, therefore resulting in the increase of the plant lifetime overall revenue.

EASY TO MONITOR

The Freesun app is the easiest way to monitor the status of our inverters. All our inverters come with built-in wifi, allowing remote connectivity to any smart device for detailed updates and information without the need to open cabinet doors.

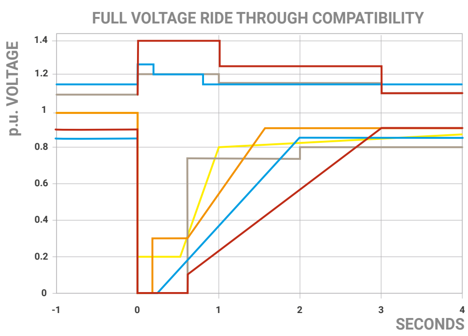
The app user-friendly interface allows quick and easy access to critical information (energy registers, production and events).

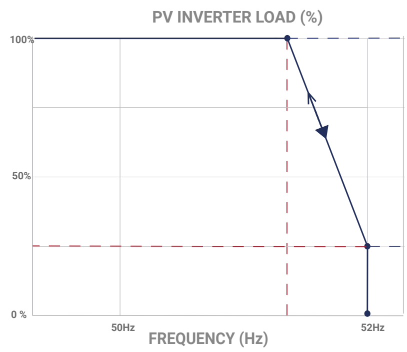


AVAILABLE INFORMATION	Grid and PV field data. Inverter and Power module data (Voltages, currents, power, temperatures, I/O status...). Weather conditions. Alarms and warnings events. Energy registers. Others.
FEATURES	Easy Wireless connection. Comprehensive interface. Real time data. Save and copy settings.
LANGUAGE	English, Spanish.
SYSTEM REQUIREMENTS	iOS or Android devices.
SETTINGS CONTROL	Yes.

DYNAMIC GRID SUPPORT

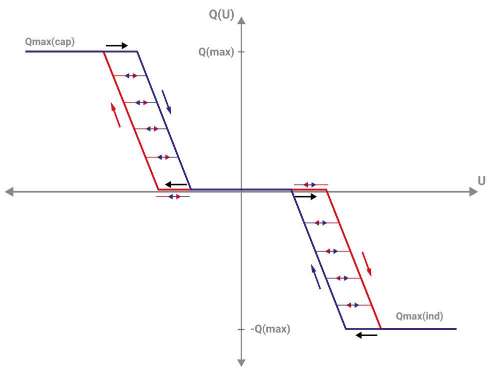
HEM firmware includes the latest utility interactive features (LVRT, OVRT, FRS, FRT, Anti-islanding, active and reactive power curtailment…), and can be configured to meet specific utility requirements.

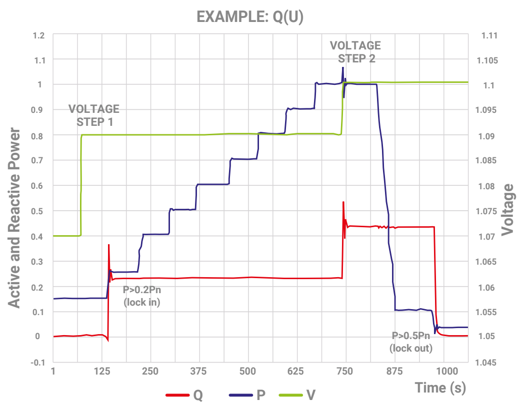




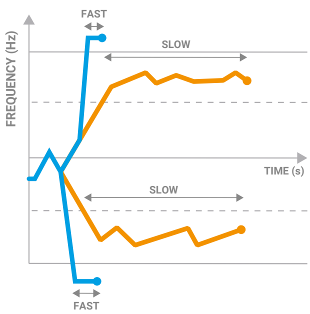
Low Voltage Ride Through (LVRT or ZVRT). Inverters can withstand any voltage dip or profile required by the local utility. The inverter can immediately feed the fault with full reactive current, as long as the protection limits are not exceeded.

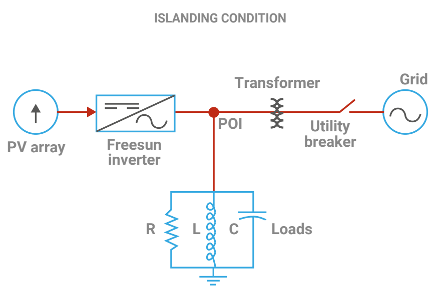
Frequency Regulation System (FRS). Frequency droop algorithm curtails the active power along a preset characteristic curve supporting grid stabilization.





Q(V) curve. It is a dynamic voltage control function which provides reactive power in order to maintain the voltage as close as possible to its nominal value.



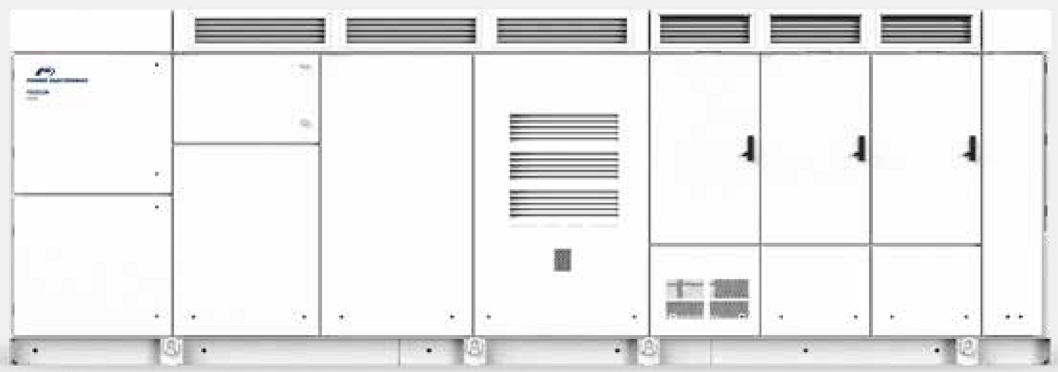


Frequency Ride Through (FRT). Freesun solar inverters have flexible frequency protection settings and can be easily adjusted to comply with future requirements.

Anti-islanding. This protection combines passive and active methods that eliminates nuisance tripping and reduces grid distortion according to IEC 62116 and IEEE1547.

FRONT VIEW

BACK VIEW



TECHNICAL CHARACTERISTICS HEM

REFERENCE		FS3510M
OUTPUT	AC Output Power (kVA/kW) @50°C [1]	3510
	AC Output Power (kVA/kW) @40°C [1]	3630
	Operating Grid Voltage (VAC) [2]	34.5kV ±10%
	Operating Grid Frequency (Hz)	50Hz/60Hz
	Current Harmonic Distortion (THDi)	< 3% per IEEE519
	Power Factor (cosine phi) [3]	0.5 leading … 0.5 lagging adjustable / Reactive Power injection at night
INPUT	MPPt @full power (VDC)	934V-1310V
	Maximum DC voltage	1500V
	Number of PV inputs [2]	Up to 36
	Number of Freemaq DC/DC inputs [4]	Up to 6
	Max. DC continuous current (A) [4]	3970
	Max. DC short circuit current (A) [4]	6000
EFFICIENCY & AUXILIARY SUPPLY	Efficiency (Max) (η)	98% including MV transformer (preliminary)
	CEC (η)	98% including MV transformer (preliminary)
	Max. Power Consumption (KVA)	20
CABINET	Dimensions [WxDxH] (ft)	21.7 x 7 x 7
	Dimensions [WxDxH] (m)	6.6 x 2.2 x 2.2
	Weight (lb)	30865
	Weight (kg)	14000
	Type of ventilation	Forced air cooling
ENVIRONMENT	Degree of protection	NEMA 3R - IP54
	Permissible Ambient Temperature	-35°C to +60°C / >50°C Active Power derating
	Relative Humidity	4% to 100% non condensing
	Max. Altitude (above sea level) [5]	2000m
	Noise level [6]	< 79 dBA
CONTROL INTERFACE	Interface	Graphic Display
	Communication protocol	Modbus TCP
	Plant Controller Communication	Optional
	Keyed ON/OFF switch	Standard
PROTECTIONS	Ground Fault Protection	GFDI and Isolation monitoring device
	General AC Protection	MV Switchgear (configurable)
	General DC Protection	Fuses
	Overvoltage Protection	AC, DC Inverter and auxiliary supply type 2
CERTIFICATIONS	Safety	UL 1741, CSA 22.2 No.107.1-01, UL 62109-1, IEC 62109-1, IEC 62109-2
	Compliance	NEC 2014 / NEC 2017 (optional)
	Utility interconnect	IEEE 1547.1-2005 / UL 1741 SA-Sept. 2016

[1] Values at 1.00•Vac nom and cos Φ= 1. Consult Power Electronics for derating curves.
[2] Consult Power Electronics for other configurations.
[3] Consult P-Q charts available: $Q(kVAr)=\sqrt{(S(kVA)^2-P(kW)^2)}$.
[4] Consult Power Electronics for Freemaq DC/DC connection configurations.
[5] Consult Power Electronics for other altitudes.
[6] Readings taken 1 meter from the back of the unit.

TECHNICAL CHARACTERISTICS HEM

REFERENCE		FS3430M
OUTPUT	AC Output Power (kVA/kW) @50°C [1]	3430
	AC Output Power (kVA/kW) @40°C [1]	3550
	Operating Grid Voltage (VAC) [2]	34.5kV ±10%
	Operating Grid Frequency (Hz)	50Hz/60Hz
	Current Harmonic Distortion (THDi)	< 3% per IEEE519
	Power Factor (cosine phi) [3]	0.5 leading … 0.5 lagging adjustable / Reactive Power injection at night
INPUT	MPPt @full power (VDC)	913V-1310V
	Maximum DC voltage	1500V
	Number of PV inputs [2]	Up to 36
	Number of Freemaq DC/DC inputs [4]	Up to 6
	Max. DC continuous current (A) [4]	3970
	Max. DC short circuit current (A) [4]	6000
EFFICIENCY & AUXILIARY SUPPLY	Efficiency (Max) (η)	98% including MV transformer (preliminary)
	CEC (η)	98% including MV transformer (preliminary)
	Max. Power Consumption (KVA)	20
CABINET	Dimensions [WxDxH] (ft)	21.7 x 7 x 7
	Dimensions [WxDxH] (m)	6.6 x 2.2 x 2.2
	Weight (lb)	30865
	Weight (kg)	14000
	Type of ventilation	Forced air cooling
ENVIRONMENT	Degree of protection	NEMA 3R - IP54
	Permissible Ambient Temperature	-35°C to +60°C / >50°C Active Power derating
	Relative Humidity	4% to 100% non condensing
	Max. Altitude (above sea level) [5]	2000m
	Noise level [6]	< 79 dBA
CONTROL INTERFACE	Interface	Graphic Display
	Communication protocol	Modbus TCP
	Plant Controller Communication	Optional
	Keyed ON/OFF switch	Standard
PROTECTIONS	Ground Fault Protection	GFDI and Isolation monitoring device
	General AC Protection	MV Switchgear (configurable)
	General DC Protection	Fuses
	Overvoltage Protection	AC, DC Inverter and auxiliary supply type 2
CERTIFICATIONS	Safety	UL 1741, CSA 22.2 No.107.1-01, UL 62109-1, IEC 62109-1, IEC 62109-2
	Compliance	NEC 2014 / NEC 2017 (optional)
	Utility interconnect	IEEE 1547.1-2005 / UL 1741 SA-Sept. 2016

[1] Values at 1.00•Vac nom and cos Φ= 1. Consult Power Electronics for derating curves.
[2] Consult Power Electronics for other configurations.
[3] Consult P-Q charts available: $Q(kVAr)=\sqrt{(S(kVA)^2-P(kW)^2)}$.
[4] Consult Power Electronics for Freemaq DC/DC connection configurations.
[5] Consult Power Electronics for other altitudes.
[6] Readings taken 1 meter from the back of the unit.

TECHNICAL CHARACTERISTICS HEM

REFERENCE		FS3350M
OUTPUT	AC Output Power (kVA/kW) @50°C [1]	3350
	AC Output Power (kVA/kW) @40°C [1]	3465
	Operating Grid Voltage (VAC) [2]	34.5kV ±10%
	Operating Grid Frequency (Hz)	50Hz/60Hz
	Current Harmonic Distortion (THDi)	< 3% per IEEE519
	Power Factor (cosine phi) [3]	0.5 leading … 0.5 lagging adjustable / Reactive Power injection at night
INPUT	MPPt @full power (VDC)	891V-1310V
	Maximum DC voltage	1500V
	Number of PV inputs [2]	Up to 36
	Number of Freemaq DC/DC inputs [4]	Up to 6
	Max. DC continuous current (A) [4]	3970
	Max. DC short circuit current (A) [4]	6000
EFFICIENCY & AUXILIARY SUPPLY	Efficiency (Max) (η)	98% including MV transformer (preliminary)
	CEC (η)	97.5% including MV transformer (preliminary)
	Max. Power Consumption (KVA)	20
CABINET	Dimensions [WxDxH] (ft)	21.7 x 7 x 7
	Dimensions [WxDxH] (m)	6.6 x 2.2 x 2.2
	Weight (lb)	30865
	Weight (kg)	14000
	Type of ventilation	Forced air cooling
ENVIRONMENT	Degree of protection	NEMA 3R - IP54
	Permissible Ambient Temperature	-35°C to +60°C / >50°C Active Power derating
	Relative Humidity	4% to 100% non condensing
	Max. Altitude (above sea level) [5]	2000m
	Noise level [6]	< 79 dBA
CONTROL INTERFACE	Interface	Graphic Display
	Communication protocol	Modbus TCP
	Plant Controller Communication	Optional
	Keyed ON/OFF switch	Standard
PROTECTIONS	Ground Fault Protection	GFDI and Isolation monitoring device
	General AC Protection	MV Switchgear (configurable)
	General DC Protection	Fuses
	Overvoltage Protection	AC, DC Inverter and auxiliary supply type 2
CERTIFICATIONS	Safety	UL 1741, CSA 22.2 No.107.1-01, UL 62109-1, IEC 62109-1, IEC 62109-2
	Compliance	NEC 2014 / NEC 2017 (optional)
	Utility interconnect	IEEE 1547.1-2005 / UL 1741 SA-Sept. 2016

[1] Values at 1.00•Vac nom and cos Φ= 1. Consult Power Electronics for derating curves.
[2] Consult Power Electronics for other configurations.
[3] Consult P-Q charts available: $Q(kVAr)=\sqrt{(S(kVA)^2-P(kW)^2)}$.
[4] Consult Power Electronics for Freemaq DC/DC connection configurations.
[5] Consult Power Electronics for other altitudes.
[6] Readings taken 1 meter from the back of the unit.

TECHNICAL CHARACTERISTICS HEM

REFERENCE		FS3270M
OUTPUT	AC Output Power (kVA/kW) @50°C [1]	3270
	AC Output Power (kVA/kW) @40°C [1]	3380
	Operating Grid Voltage (VAC) [2]	34.5kV ±10%
	Operating Grid Frequency (Hz)	50Hz/60Hz
	Current Harmonic Distortion (THDi)	< 3% per IEEE519
	Power Factor (cosine phi) [3]	0.5 leading … 0.5 lagging adjustable / Reactive Power injection at night
INPUT	MPPt @full power (VDC)	870V-1310V
	Maximum DC voltage	1500V
	Number of PV inputs [2]	Up to 36
	Number of Freemaq DC/DC inputs [4]	Up to 6
	Max. DC continuous current (A) [4]	3970
	Max. DC short circuit current (A) [4]	6000
EFFICIENCY & AUXILIARY SUPPLY	Efficiency (Max) (η)	98% including MV transformer (preliminary)
	CEC (η)	98% including MV transformer (preliminary)
	Max. Power Consumption (KVA)	20
CABINET	Dimensions [WxDxH] (ft)	21.7 x 7 x 7
	Dimensions [WxDxH] (m)	6.6 x 2.2 x 2.2
	Weight (lb)	30865
	Weight (kg)	14000
	Type of ventilation	Forced air cooling
ENVIRONMENT	Degree of protection	NEMA 3R - IP54
	Permissible Ambient Temperature	-35°C to +60°C / >50°C Active Power derating
	Relative Humidity	4% to 100% non condensing
	Max. Altitude (above sea level) [5]	2000m
	Noise level [6]	< 79 dBA
CONTROL INTERFACE	Interface	Graphic Display
	Communication protocol	Modbus TCP
	Plant Controller Communication	Optional
	Keyed ON/OFF switch	Standard
PROTECTIONS	Ground Fault Protection	GFDI and Isolation monitoring device
	General AC Protection	MV Switchgear (configurable)
	General DC Protection	Fuses
	Overvoltage Protection	AC, DC Inverter and auxiliary supply type 2
CERTIFICATIONS	Safety	UL 1741, CSA 22.2 No.107.1-01, UL 62109-1, IEC 62109-1, IEC 62109-2
	Compliance	NEC 2014 / NEC 2017 (optional)
	Utility interconnect	IEEE 1547.1-2005 / UL 1741 SA-Sept. 2016

[1] Values at 1.00•Vac nom and cos Φ= 1. Consult Power Electronics for derating curves.
[2] Consult Power Electronics for other configurations.
[3] Consult P-Q charts available: $Q(kVAr)=\sqrt{S(kVA)^2-P(kW)^2}$.
[4] Consult Power Electronics for Freemaq DC/DC connection configurations.
[5] Consult Power Electronics for other altitudes.
[6] Readings taken 1 meter from the back of the unit.

TECHNICAL CHARACTERISTICS HEM

REFERENCE		FS3190M
OUTPUT	AC Output Power (kVA/kW) @50°C [1]	3190
	AC Output Power (kVA/kW) @40°C [1]	3300
	Operating Grid Voltage (VAC) [2]	34.5kV ±10%
	Operating Grid Frequency (Hz)	50Hz/60Hz
	Current Harmonic Distortion (THDi)	< 3% per IEEE519
	Power Factor (cosine phi) [3]	0.5 leading … 0.5 lagging adjustable / Reactive Power injection at night
INPUT	MPPt @full power (VDC)	849V-1310V
	Maximum DC voltage	1500V
	Number of PV inputs [2]	Up to 36
	Number of Freemaq DC/DC inputs [4]	Up to 6
	Max. DC continuous current (A) [4]	3970
	Max. DC short circuit current (A) [4]	6000
EFFICIENCY & AUXILIARY SUPPLY	Efficiency (Max) (η)	98% including MV transformer (preliminary)
	CEC (η)	98% including MV transformer (preliminary)
	Max. Power Consumption (KVA)	20
CABINET	Dimensions [WxDxH] (ft)	21.7 x 7 x 7
	Dimensions [WxDxH] (m)	6.6 x 2.2 x 2.2
	Weight (lb)	30865
	Weight (kg)	14000
	Type of ventilation	Forced air cooling
ENVIRONMENT	Degree of protection	NEMA 3R - IP54
	Permissible Ambient Temperature	-35°C to +60°C / >50°C Active Power derating
	Relative Humidity	4% to 100% non condensing
	Max. Altitude (above sea level) [5]	2000m
	Noise level [6]	< 79 dBA
CONTROL INTERFACE	Interface	Graphic Display
	Communication protocol	Modbus TCP
	Plant Controller Communication	Optional
	Keyed ON/OFF switch	Standard
PROTECTIONS	Ground Fault Protection	GFDI and Isolation monitoring device
	General AC Protection	MV Switchgear (configurable)
	General DC Protection	Fuses
	Overvoltage Protection	AC, DC Inverter and auxiliary supply type 2
CERTIFICATIONS	Safety	UL 1741, CSA 22.2 No.107.1-01, UL 62109-1, IEC 62109-1, IEC 62109-2
	Compliance	NEC 2014 / NEC 2017 (optional)
	Utility interconnect	IEEE 1547.1-2005 / UL 1741 SA-Sept. 2016

[1] Values at 1.00•Vac nom and cos Φ= 1. Consult Power Electronics for derating curves.
[2] Consult Power Electronics for other configurations.
[3] Consult P-Q charts available: $Q(kVAr)=\sqrt{(S(kVA)^2-P(kW)^2)}$.
[4] Consult Power Electronics for Freemaq DC/DC connection configurations.
[5] Consult Power Electronics for other altitudes.
[6] Readings taken 1 meter from the back of the unit.

Appendix B

Project Equipment Sound Modeling Analysis Results

Operational Sound Modeling Results - Bellflower Solar Project

Receptor Name	Easting (UTM 16)	Northing (UTM 16)	Excepted Operational Sound (dBA) - 0.5 GA
R-001	634,540	4,406,992	30.5
R-002	634,609	4,403,658	33.4
R-003	633,686	4,406,877	25.5
R-004	634,455	4,406,068	32.4
R-005	637,743	4,406,534	31.9
R-006	635,539	4,402,079	24.2
R-007	634,676	4,404,422	36.0
R-008	636,468	4,402,153	24.2
R-009	636,158	4,406,293	40.8
R-010	635,474	4,402,350	25.7
R-011	637,905	4,404,011	25.9
R-012	637,739	4,406,590	31.9
R-013	635,695	4,402,562	27.1
R-014	635,514	4,402,734	28.2
R-015	635,424	4,405,311	40.7
R-016	637,329	4,403,815	29.4
R-017	635,497	4,403,008	30.3
R-018	636,115	4,406,101	40.5
R-019	636,135	4,403,069	31.3
R-020	636,166	4,403,077	31.3
R-021	636,184	4,406,741	39.6
R-022	636,162	4,403,169	32.4
R-023	635,564	4,403,201	32.0
R-024	634,683	4,403,292	30.6
R-025	634,610	4,403,483	31.9
R-026	634,697	4,403,521	33.0
R-027	634,291	4,403,555	29.7
R-028	635,431	4,403,567	35.3
R-029	636,833	4,403,591	32.9
R-030	636,973	4,403,646	31.9
R-031	635,402	4,403,644	36.2
R-032	634,036	4,403,650	28.2
R-033	634,118	4,403,660	28.9
R-034	635,424	4,403,699	36.7
R-035	635,298	4,403,703	37.5
R-036	634,035	4,403,730	28.5
R-037	634,172	4,403,752	29.6
R-038	634,605	4,403,798	34.5
R-039	636,949	4,403,810	33.3
R-040	637,329	4,403,815	29.4
R-041	637,905	4,404,011	25.9
R-042	634,676	4,404,422	36.0
R-043	636,228	4,404,545	40.0
R-044	637,841	4,404,589	26.8
R-045	634,572	4,404,637	34.1

Operational Sound Modeling Results - Bellflower Solar Project

Receptor Name	Easting (UTM 16)	Northing (UTM 16)	Excepted Operational Sound (dBA) - 0.5 GA
R-046	634,628	4,404,852	34.3
R-047	635,424	4,405,311	40.7
R-048	636,549	4,405,318	34.8
R-049	635,675	4,405,379	40.3
R-050	635,191	4,405,386	41.2
R-051	636,335	4,405,390	36.7
R-052	638,134	4,405,425	26.1
R-053	633,968	4,405,459	29.0
R-054	637,835	4,405,475	27.6
R-055	637,957	4,405,592	27.2
R-056	634,438	4,405,723	32.5
R-057	634,544	4,405,802	33.4
R-058	636,130	4,405,843	38.8
R-059	636,049	4,406,070	41.2
R-060	638,164	4,406,090	26.9
R-061	636,115	4,406,101	40.5
R-062	638,074	4,406,134	27.6
R-063	637,963	4,406,151	28.5
R-064	638,057	4,406,169	27.8
R-065	637,926	4,406,176	28.9
R-066	638,081	4,406,185	27.6
R-067	634,451	4,406,184	32.3
R-068	636,158	4,406,293	40.8
R-069	637,743	4,406,534	31.9
R-070	637,739	4,406,590	31.9
R-071	636,187	4,406,601	41.4
R-072	636,147	4,406,622	40.6
R-073	636,153	4,406,688	40.1
R-074	634,459	4,406,718	31.2
R-075	636,184	4,406,741	39.6
R-076	637,723	4,406,757	31.4
R-077	633,810	4,406,782	26.4
R-078	636,173	4,406,794	38.6
R-079	634,510	4,406,815	31.2
R-080	633,742	4,406,822	26.0
R-081	633,612	4,406,865	25.2
R-082	633,925	4,406,882	26.8
R-083	633,782	4,406,883	26.0
R-084	633,841	4,406,888	26.3
R-085	633,742	4,406,890	25.8
R-086	633,873	4,406,885	26.5
R-087	633,644	4,406,895	25.3
R-088	633,909	4,406,908	26.6
R-089	634,006	4,406,907	27.2
R-090	633,889	4,406,913	26.5

Operational Sound Modeling Results - Bellflower Solar Project

Receptor Name	Easting (UTM 16)	Northing (UTM 16)	Excepted Operational Sound (dBA) - 0.5 GA
R-091	633,810	4,406,943	26.0
R-092	634,148	4,406,960	27.9
R-093	633,957	4,406,967	26.7
R-094	634,434	4,406,972	29.8
R-095	633,979	4,406,976	26.8
R-096	633,682	4,406,981	25.2
R-097	633,618	4,406,985	24.9
R-098	634,123	4,406,991	27.6
R-099	633,745	4,406,989	25.5
R-100	637,818	4,406,992	28.9
R-101	633,827	4,406,998	25.9
R-102	633,785	4,406,993	25.7
R-103	633,805	4,406,997	25.8
R-104	633,706	4,406,992	25.3
R-105	633,858	4,407,000	26.1
R-106	633,637	4,407,004	25.0
R-107	634,321	4,407,002	28.9
R-108	633,940	4,407,012	26.5
R-109	633,880	4,407,012	26.2
R-110	633,904	4,407,012	26.3
R-111	634,455	4,407,009	29.8
R-112	633,684	4,407,023	25.1
R-113	633,751	4,407,026	25.5
R-114	634,001	4,407,025	26.8
R-115	633,649	4,407,040	24.9
R-116	633,974	4,407,040	26.6
R-117	633,708	4,407,045	25.2
R-118	633,752	4,407,044	25.4
R-119	633,913	4,407,044	26.3
R-120	633,683	4,407,057	25.1
R-121	633,882	4,407,063	26.0
R-122	633,647	4,407,067	24.9
R-123	633,777	4,407,066	25.5
R-124	633,817	4,407,070	25.7
R-125	633,748	4,407,069	25.3
R-126	633,854	4,407,071	25.9
R-127	633,928	4,407,071	26.2
R-128	633,898	4,407,067	26.1
R-129	634,308	4,407,074	28.4
R-130	635,039	4,407,078	33.4
R-131	633,748	4,407,100	25.2
R-132	633,725	4,407,100	25.1
R-133	633,830	4,407,102	25.6
R-134	633,880	4,407,104	25.9
R-135	633,703	4,407,103	25.0

Operational Sound Modeling Results - Bellflower Solar Project

Receptor Name	Easting (UTM 16)	Northing (UTM 16)	Excepted Operational Sound (dBA) - 0.5 GA
R-136	633,904	4,407,106	26.0
R-137	633,779	4,407,107	25.4
R-138	633,927	4,407,108	26.1
R-139	633,678	4,407,118	24.9
R-140	635,522	4,407,122	34.1
R-141	633,881	4,407,152	25.8
R-142	634,284	4,407,165	27.9
R-143	633,948	4,407,164	26.0
R-144	633,737	4,407,172	25.0
R-145	635,997	4,407,176	33.7
R-146	633,837	4,407,176	25.5
R-147	633,704	4,407,175	24.8
R-148	633,772	4,407,179	25.1
R-149	633,804	4,407,178	25.3
R-150	633,880	4,407,182	25.6
R-151	635,758	4,407,176	33.8
R-152	635,885	4,407,190	33.7
R-153	633,852	4,407,214	25.4
R-154	633,773	4,407,215	25.0
R-155	633,819	4,407,219	25.2
R-156	636,155	4,407,222	32.9
R-157	635,382	4,407,226	32.7
R-158	633,875	4,407,230	25.5
R-159	633,732	4,407,232	24.8
R-160	634,097	4,407,235	26.6
R-161	633,941	4,407,243	25.7
R-162	635,511	4,407,241	32.8
R-163	633,772	4,407,271	24.9
R-164	636,474	4,407,270	31.8
R-165	636,647	4,407,274	31.4
R-166	633,878	4,407,276	25.3
R-167	636,579	4,407,287	31.4
R-168	633,998	4,407,350	25.6
R-169	636,585	4,407,395	30.5
R-170	636,736	4,407,399	30.2
R-171	636,642	4,407,397	30.4
R-172	636,908	4,407,411	29.8
R-173	637,166	4,407,440	28.9
R-174	634,915	4,407,658	27.8
R-175	634,902	4,407,808	26.8
R-176	637,706	4,407,891	24.4
R-177	637,747	4,408,013	23.7
R-178	636,138	4,408,089	26.2