

	PURCHASE SPECIFICATION	PS-439-1350
	GROUP: PHOTOVOLTAICS	Rev No: 01
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TECHNICAL SPECIFICATION

FOR

HYBRID SOLAR INVERTER CUM CHARGE CONTROLLER

Revision details:

R01 dated 10/9/2020: Changes highlighted

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Date

19/8/2020

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1.0 INTRODUCTION:

This technical specification provides BHEL's requirement for Design, Engineering, Manufacture, Supply, I&C support at site, Training and Warranty conditions of Hybrid Solar Inverter cum Charge Controllers (hereinafter referred to as inverters). These inverters are meant for generating electricity from solar photovoltaic panels and also charge Nickel-Cadmium batteries for supplying power to various emergency loads in solar mini grids. These mini grids will be installed at 221 community health centers located at different places spread within Kaduna State of Nigeria, Africa. List of site locations is enclosed in [Annexure-1](#).

2.0 SCOPE OF VENDOR:

- Supply of Hybrid Solar inverter cum charge controllers of ratings 5 kW, 10 kW and 15 kW including spare inverters – Quantities as per BHEL RFQ document
- Support at site for Installation & Commissioning
- Training to customer's engineers & integrator at site
- Service support during Comprehensive Warranty period

3.0 Methodology of operation:

The proposed Solar mini grid has to work in conjunction with the grid or DG sets in either of the following two scenarios:

- In the day time the first priority of the inverter shall be to charge the battery. Whenever battery reaches float charge, inverter shall be supplying the connected load in conjunction with the grid or DG.
- It shall function as a stand-alone power plant feeding the connected loads when grid is not available. Most of the sites do not have DG or grid, only few sites will have.

In case inverter is not functioning, there shall be provision to bypass the load on to grid or DG. At any point there shall not be any back feeding to the DG. Vendor can suggest the best operating scenario as per inverter design for stable operation with optimum utilization of solar energy available and using Ni-Cd batteries for energy storage.

Battery based solar inverter cum charge controller shall be a single panel. Charge controller will be integral part of inverter (**separate units of charge controller and inverter placed in a single enclosure is not acceptable**). Charge controller is the front end of the solar inverter which will have the MPPT charger in order to charge the battery and shall be internally coupled with inverter section of the solar inverter.

The charge controller shall be having the following functionalities:

- Charge controller shall be capable of 3 step (float, boost and trickle) charging, depending on the state of charge of the battery. Inverter/charge controller shall utilize solar/grid power to charge the battery bank till battery reaches float with solar as priority for charging the battery.
- Once the battery cells reach float, solar power generated shall be used to meet the connected site load. ~~The provision for grid export is optional and shall be set point controllable if not required.~~
- In general, the priority of supply to the load should be solar, grid and battery.

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(d) Once the battery cell drops below the pre-determined voltage (say 1.1 V_{pc}), load should be ~~switched-over~~ disconnected from battery ~~to-grid~~ automatically. Solar/grid charging shall commence and continue till battery reaches float. After battery cells reaches float voltage, charging shall be adjusted in such a way to maintain the float voltage.

All necessary equipment required for the above operation shall be considered in the scope of supply by the vendor.

4.0 TECHNICAL SPECIFICATIONS:

PARAMETER	DESCRIPTION			Vendor Compliance (YES/ NO)
INVERTER RATING	5 kVA	10 kVA	15 kVA	
PV ARRAY				
PV Module	BHEL make SPV Modules of 315Wp rating			
PV nominal Capacity	5 kWp	10 kWp	15 kWp	
Total Number of Modules	16	35	48	
No. of PV modules in series	4	7	12	
String open circuit voltage, Voc	181.2 V	317.1 V	543.6 V	
String MPP voltage, Vmp	150.44 V	263.27 V	451.32 V	
String MPP Current, Imp	8.38 A	8.38 A	8.38 A	
No. of inputs to Inverter	1	1	1	
SOLAR CHARGE CONTROLLER (Integral part of Inverter)				
Nominal PV array Capacity	5 kWp	10 kWp	15 kWp	
Max PV array capacity	Vendor to specify			
Controller type	MPPT	MPPT	MPPT	
No. of MPPT channels	1	1	1	
Prioritization of power consumption	Prioritization of power consumption shall be possible to set as per requirement			
Solar & Grid Charger Output current (Minimum)	70A	60A	50A	
Battery Temperature compensation	Shall be available. Settings shall be as per battery manufacturer recommendations			
BATTERY BANK				
Nominal bank voltage	48 V DC	120 V DC	240 V DC	
Mandatory battery Type	Ni-Cd	Ni-Cd	Ni-Cd	
Compatible battery types	Vendor to specify			
Capacity used	900 AH@C5	720 AH@C5	540 AH@C5	
AH Capacity Range	Vendor to confirm inverter suits for any AH capacity of battery, with ability to scale up PV array size, up to maximum PV capacity rating of the inverter cum charge controller.			
Nominal cell voltage	1.2 V	1.2 V	1.2 V	
Float charge voltage	Approx. 1.42 V/ cell			
Boost charge voltage	Approx. 1.65 to 1.7 V/ cell			

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Charger compatibility	Vendor to confirm battery shall be charged as per battery manufacturer recommendations.			
INVERTER				
Continuous rating	5 kVA	10 kVA	15 kVA	
Inverter Type	Pure Sine wave	Pure Sine wave	Pure Sine wave	
DC Input voltage range	To match with the PV array configuration given above. Vendor shall furnish the details.			
Maximum DC Input voltage				
Nominal Output voltage	230/ 240 V AC	230/ 240 V AC	415 V AC	
No. of phases / Connection type	Single Phase/ 2-wire (L-N)	Single Phase/ 2-wire (L-N)	Three Phase/ 4-wire (L-N)	
Nominal frequency	50 Hz	50 Hz	50 Hz	
Efficiency	Min. 87%	Min. 87%	Min. 87%	
Load power factor	0.8 to Unity or better	0.8 to Unity or better	0.8 to Unity or better	
Voltage Regulation	+/- 2%	+/- 2%	+/- 2%	
Galvanic Isolation	Inbuilt isolation transformer at inverter output			
Protections				
PV side	Reverse polarity, Surge protection			
Battery side	Reverse polarity, Over/Under voltage, Current limit			
Load side	Over load, Short Circuit, Over/Under voltage			
System Protection	Over temperature protection			
Vendor shall specify additional protections for the safe operation of the PV power plant apart from the minimum specified above.				
Display parameters on Inverter screen				
Array	Voltage, Current, Power			
Battery	Voltage, Current			
Output	Voltage, Current, Power			
Indication	Display of mode of operation			
Network and communication				
Remote monitoring	Remote monitoring provision shall be available in the inverter. Necessary SIM card for GPRS connection / internet connection will be arranged by customer			
Network communication to controller and other components	Provision for communication over Modbus RS232. Display & logging of DC and AC parameters shall be available with memory to store data. There shall be provision to monitor downloading the parameters through PC/Laptop Remotely through GPRS shall be provided.			
Miscellaneous				
Installation	Indoor (Non-airconditioned) and floor mounted			

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Enclosure protection	IP20 or better	
Ambient Temperature	0 to 50°C	
Humidity	Max 95% non-condensing	
Cable termination type	Bus bar type with ring type lugs Vendor to specify along with type of lug	
Applicable standards	Compliance to IEC standards: IEC 61683 & IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-14, IEC 60068-2-30 certificates for the same rating inverters as specified above or similar rating as below: Similar rating of inverter is defined as below: For 5 kVA inverter: 5kVA or above rating, single phase output and any DC voltage, For 10 kVA inverter: 10kVA or above rating, single phase output and any DC voltage, For 15 kVA inverter: 15 kVA or above rating, three phase output and any DC voltage. Vendor shall produce type test reports for same/ similar rating inverter along with offer. In case type test reports of similar rating inverters are produced, vendor shall also submit an undertaking on letterhead along with offer that the type tests will be conducted on same rating of the inverters and submitted to BHEL within 4 weeks after receipt of Purchase order. No additional cost implication shall be accepted by BHEL for conducting the type tests and shall deemed to be included in the quoted price.	
Auxiliary power requirement for inverters	Inverters shall draw power from solar or grid or battery for operation of inverter. No separate auxiliary power supply will be provided.	
Isolation Mechanism for Solar, grid, battery and load connections	Fuse/ MCB/ MCCB. Vendor to specify	
Dimensions	Vendor to specify	
Weight	Vendor to specify	
Busbars (if applicable)	Suitable size of Tinned copper Busbars shall be provided. Busbar sizing calculations shall be provided during detailed engineering. Bus bars (both AC and DC) shall be suitably colour coded.	
Cable entry	Rear entry preferable. If the cable entry is from bottom, suitable stand shall be supplied for	

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	facilitating cable entry without construction of cable trenches.	
Gland plates (if any)	Drilled Gland plates shall be provided for DC and AC cables with holes to accommodate the cable glands.	
Cable glands (if any)	If glands are required for termination of DC and AC cables, same shall supplied along with inverter.	
Cable lugs	Cable lugs will be supplied by BHEL/ BHEL's integrator. Vendor has to specify the exact termination details	
Cable termination hardware	Cable termination hardware (Bolts, Nuts & washers) will be supplied by BHEL/ BHEL's integrator.	
Panel Construction	Vendor shall design the panel for withstanding the high temperature tropical conditions of Nigeria. Vendor has to submit the construction details along with finish to BHEL for approval. All hardware used shall be SS304.	
Base channel	Vendor to specify the details.	
Painting	Epoxy based powder coating. Powder coating shall meet the requirement of IS 13871. Paint shade shall be informed during detailed engineering.	
Earthing terminals as per relevant standards	Earthing terminals or busbars shall be provided using tinned copper of suitable cross section. Terminals shall be brought out to facilitate external connections.	
Special Instructions	Special conformal coating on all PCB cards to be coated, if required, to withstand the high temperature tropical conditions of Nigeria	
PACKING	Shipping and packing shall be as per instructions enclosed. Each set of inverter shall be packed separately as the site locations are different. Any changes in shipping and packing methodology shall be subject to BHEL approval	
BHEL Monogram	BHEL Monogram shall be fixed on all inverters. Design of monogram will be provided by BHEL	

5.0 Documents to be submitted along with offer without which offer shall be liable for rejection:

1. Tentative Data sheets and Drawings – GA, SLD, BOM, Mounting arrangement & weight etc.
2. Filled in values/details wherever the same is asked for in BHEL technical specifications.
3. Type Test certificates for all specified standards
4. Vendor shall provide clause wise compliance to BHEL specification with sign and seal on every page.

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In case of any clarifications needed in this specification, the same needs to be communicated in writing at least five days earlier to the technical bid opening date.

6.0 Documents to be submitted for BHEL approval within 1 week after receipt of Purchase order

1. Technical Data sheets of all equipment
2. Drawings – GA, SLD, BOM, Mounting arrangement etc. of all equipment
3. Type test certificates and reports of all equipment
4. Manufacturing Quality Plan (MQP) & inspection plan of all equipment indicating all tests/checks per relevant IS/IEC standards, as called in this document and any other relevant standards shall be submitted to BHEL for approval.
5. Installation & Commissioning Manual of all equipment
6. Checklist for commissioning and validating the set points
7. Operation and maintenance manual of all equipment

7.0 Support from vendor during document approval phase

During the phase of approval of design / engineering / quality documents (GA, GTP, BOM, MQP, Test report etc.), it will be required to hold in-depth discussions with BHEL/customer to provide clarifications through clear understanding of technical queries. Accordingly, when needed, vendor shall hold direct (across-the-table) discussions or through Video-conference with BHEL (Bangalore office) and/ or customer to eliminate undue time delays.

8.0 Inspection and testing of equipment at vendor works:

BHEL and/ or BHEL customer shall witness the testing of inverters as per relevant IS/IEC standards/inspection plan. All routine tests and acceptance tests on final products shall be done as per MQP approved by the BHEL. Factory test report shall be submitted to BHEL along with inspection call. BHEL reserves right to witness the test/inspection or waive the test/inspection. Schedule of inspection shall be intimated to BHEL at least one week in advance. Waiver of inspection does not relieve the vendor's responsibility for compliance to product specification.

Following are the minimum tests to be conducted but not limited to (sampling plan for tests will be decided during approval of MQP):

- a) HV and IR tests
- b) Functional tests (Including testing with solar & battery)
- c) Load testing of inverter for verification of display parameters and operation of inverter at 25%, 50%, 75% and 100% loads
- d) Heat Run Test at rated full load
- e) Protection tests (by direct method or simulation method)

9.0 SONCAP Certification:

The material being exported to Nigeria shall comply to Standards Organization of Nigeria Conformity Assessment Programme (SONCAP). Vendor may refer www.son.gov.ng for the details.

It is the responsibility of the vendor to provide the valid SONCAP certificate to BHEL for the shipment of the material.

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10.0 Supervision/assistance for Commissioning:

Vendor shall depute their service engineer for a visit in Kaduna, Nigeria for testing and commissioning of inverters as per the intimation of BHEL. Service engineer shall carry all the required accessories, laptop, tool kits & measuring instruments required for the commissioning of the inverters. Service engineer shall also demonstrate communication and monitoring of inverter through PC/ laptop and remote monitoring of inverter.

It shall be assumed that 5 inverters shall be commissioned in a single visit. Approximately 20 days shall be considered for the commissioning of 5 inverters. A single lump-sum price shall be offered for installation and commissioning support. The lump-sum price shall include all the incidental costs for visit that will be incurred by the vendor towards the above activities including Travel, Visa charges, Insurance, medical expenses, local conveyance, boarding, lodging and any other contingency expenses which are explicitly not mentioned.

11.0 Training to BHEL's integrator and Customer:

Vendor shall train BHEL/BHEL's integrator in installation and commissioning of inverters by imparting training at vendor's works and hands-on training at five sites in the above visit. Vendor shall provide detailed installation and commissioning procedure with the necessary checklists. BHEL/BHEL's integrator shall commission the inverters at the remaining 216 sites. It is the vendor's responsibility to impart complete training to BHEL's integrator and ensure complete online support as required for commissioning of all the inverters. If any failure or internal technical problem is encountered in the equipment during commissioning of remaining 216 sites, it will be replaced free of cost by vendor. Any additional visits required to complete commissioning will be in the vendor's scope and no payment will be made by BHEL for additional visits.

During the above onsite commissioning support visit, complete training on technical features, installation & commissioning procedure, operation & maintenance aspects, trouble-shooting, data monitoring and data logging of the inverter shall be given to end customer at Renewable Energy Academy in Kaduna.

Charges incurred by the vendor towards the training to BHEL's integrator and customer shall be deemed to be included in the cost of supply of inverters. No additional payment will be made by BHEL/ end customer.

12.0 Comprehensive Warranty Support:

During the warranty period, whenever a technical problem is encountered with equipment supplied by vendor, BHEL/ end customer shall report the same to the vendor. Vendor must ensure that the problem is attended either by replacement or repair of the defective part(s)/ inverters free of cost. Charges incurred by the vendor towards repair/replacement, travel, lodging, boarding, material transportation, service and any other contingency expenditure shall be deemed to be included in the cost of equipment. No additional payment will be made by BHEL/ end customer.

Vendor shall inform the escalation matrix and procedure for attending complaints on inverters. Sufficient stock of spare components to be considered for this purpose.

Vendor shall provide optional price for additional comprehensive warranty of 3 years after completion of initial warranty period. Additional warranty may be ordered by BHEL/ end customer before expiry of initial warranty period.

Annexure-1			
List of Public Health Centres (PHCs) identified for Solar Mini-Grids Project in Kaduna State, Nigeria			
S/N	Local Government Area (LGA)	NAME OF PHC	Ratings of connected inverters (KVA)
1	Birnin Gwari	KUYELLO	5
2		TABANNI	5
3		KUTEMESHE	5
4		SAULAWA	5
5		KAMFANIN DOKA	5
6		HALADU	5
7		BIRNIN GWARI	5
8		DOGON DAWA	10
9		KAZAGE (DAMARI)	5
10		KAKANGI	5
11		RANDAGI	10
12	Chikun	CHIKUN	5
13		GWAGWADA	5
14		KAKAU	10
15		BURUKU	5
16		KURIGA	5
17		NASARAWA	5
18		SABON GARI	5
19		WADA KUJAMA	5
20		MARABAN RIDO	5
21		NARAYI	5
22		SABO TASHA	5
23		ROMI	10
24	Giwa	DANMAHAWAYI	5
25		PANHAUYA	5
26		GIWA	10
27		KAYA	5
28		WAZATA	5
29		TURAWA	5
30		KIDANDAN	5
31		SHIKA	5
32		YAKAWADA	5
33	Igabi	RIGACHIKUN	10
34		MANDO	10
35		RIGASA	5
36		SABO BIRNI	5
37		GWANDA	10
38		MARABAN JOS	5
39		JAJI	10
40		GADAN GAYAN	5
41		KWANAN FARAKWAI	5
42		IGABI	5
43		IKARA	5

S/N	Local Government Area (LGA)	NAME OF PHC	Ratings of connected inverters (KVA)
44	Ikara	PALA	5
45		MALIKANCI	5
46		SAYA-SAYA	5
47		SAULAWA	5
48		WAMBAI	5
49		AUCHAN	15
50		KUYA	5
51		PAKI	10
52	Jaba	SABON GARI CHORI	5
53		FOGYEI_Reneted	5
54		ANKUNG A	5
55		NOK	5
56		SAMBAN GIDA	5
57		KWOI	10
58		SAB-ZURO	5
59		BITARO	5
60	Jema'a	ATUKU	5
61		BARDE	5
62		GODO GODO	5
63		JAGINDI	5
64		KAFANCHAN A	5
65		KAFANCHAN B	10
66		KAGOMA	5
67		UNWAN FARI	5
68		MAIGIZO	5
69		TAKAU	5
70		KACHIA	5
71		GUMEL	5
72	Kachia	BISHINI	5
73		KATARI	5
74		DOKA	5
75		AGUNU	5
76		SABON SARKI	5
77		KURMIN MUSA	5
78		TSAUNI	5
79		ANKUWA	5
80	Kaduna North	MALALI	5
81		ZIM	10
82		H/BANKI	5
83		KABALA	5
84		JUNCTION ROAD	5
85		U/RIMI	5
86		U/DOSA	5
87		U/SHANU	15
88		UNGWAN SARKI	5
89		JOS ROAD	5

S/N	Local Government Area (LGA)	NAME OF PHC	Ratings of connected inverters (KVA)
90	Kaduna South	HAJ ASMAU AHMED	5
91		KAKURI HAUSA	5
92		KURMIN GWARI	10
93		MAKERA I	5
94		U/SANUSI	5
95		KAGORO ROAD	5
96		FAKI ROAD	5
97		T/NUPAWA	5
98		KABALA WEST	5
99		ZANGO ROAD	5
100		TUDUN WADA NORTH	10
101	Kagarko	KENYI	5
102		KWASERE	5
103		KURMIN JIBRIN	5
104		KUBACHA	5
105		DOGON KURMI	5
106		AKOTI	5
107		KAGARKO	5
108		IDDAH	10
109	Kajuru	KUKUI	5
110		IBURU	5
111		BUDA	5
112		IRI-GARI	5
113		KAJURU	5
114		KALLAH	10
115		KASUWAN MAGANI	5
116		KUFANA	5
117		TANTATU	5
118		RIMAU	5
119	Kaura	FADA	5
120		KUKUM GIDA	5
121		KAGORO	5
122		AGBAN	5
123		MALLAGUM	5
124		BONDONG	5
125		FADAN ATTAKAR	5
126		TACHIRA	5
127		KAURA	5
128	KAURU	KAURU	5
129		KAGA DAMA	5
130		DANDAURA	5
131		DOKAN KARJI	5
132		KWASSAM	5
133		KINUGU	5
134		KONO	5
135		BAKIN KOGI	5

S/N	Local Government Area (LGA)	NAME OF PHC	Ratings of connected inverters (KVA)
136		KAMARU CHAWAI	5
137		RAHAMA	5
138	KUBAU	ANCHAU	15
139		KARGI	5
140		HASKIYA	5
141		PAMBEGUA	5
142		KUBAU	5
143		MAUDE	5
144		D/WAI	5
145		ZUNTU	5
146		KARRE	5
147	KUDAN	GARU	5
148		HUNKUYI	5
149		K/WALI	10
150		SABON GARI	5
151		DOKA	5
152		TABA	10
153		KUDAN	5
154		DANGASHI	5
155	Lere	ABADASWA	5
156		KAYARDA	5
157		KUDARU	10
158		LERE	10
159		R/KURA	10
160		U/BAWA	5
161		SAMINAKA	10
162		LAZURAU	5
163	Makarfi	MAYERE	5
164		GIMI GARI	5
165		GWANKI	5
166		K/MATA	5
167		GUBUCHI	5
168		GAZARA	5
169		N/DOYA	5
170		DANDAMISA	5
171	Sabon Gari	BASAWA	5
172		HAYIN DONGO	10
173		CHIKAJI	5
174		SAKADADI	5
175		SAMARU	5
176		A/KWARI	5
177		JAMA'A	5
178		U/HGABAS	5
179		KWATA	5
180		ZABI	5
181		GWANTU	5

S/N	Local Government Area (LGA)	NAME OF PHC	Ratings of connected inverters (KVA)
182	Sanga	MAYIR	5
183		LANGA	5
184		NANDU BASHAYI	5
185		KARSHI	5
186		U/NUNGU	5
187		ABORO	5
188		WASA	5
189		F/NINZO	10
190		ANCHA	5
191		Soba	SOBA
192	GAMAGIRA		5
193	GARU		5
194	KINKIBA		5
195	RAHAMA		5
196	KWASALLO		5
197	YAKASAI		10
198	RICHIFA		5
199	AWAI		5
200	Zangon Kataf	GORA-BAFAI	5
201		FARMAN	5
202		GORA GIDA	5
203		F/KAMANTAN	5
204		MABUSHI	5
205		U/RIMI	5
206		K/MASARA	5
207		ZANGO	5
208		ZONKWA	5
209		SAKO	5
210	Zaria	WUCICIRI	5
211		DAMBO	5
212		U/DANKALI	10
213		TUKUR-TUKUR	5
214		TUDUN-WADA	5
215		D/ABBA	10
216		IYAL MEMORIAL	10
217		U/ALKALI	10
218		B/DODO	5
219		GYALLESU	10
220		U/FATIKA	5
221		DURUMI	5
TOTAL (kVA)			1300.0