

Amendment – XXVI dated 30.08.2024 to RFP documents for selection of bidder as Transmission Service Provider to establish Inter-State Transmission system for “Transmission System for Evacuation of power from potential renewable energy zone in Khavda area of Gujarat under Phase-V (8 GW): Part A” through tariff based competitive bidding process.

Sl. No.	Clause No.	Existing Provision			New/Revised Provision		
1.	4. Design Consideration RFP & TSA	SI. No.	Item Description	Parameters	Sl. No.	Item Description	Parameters
	
		8.	Minimum Short circuit level (MVA) at 400 kV KPS2 (both rectifier and inverter operation)	Sec-I: 25600 MVA and SecII: 19800 MVA (with IBR) Sec-I: 17600 MVA and SecII: 13800 MVA (without IBR) (Considering outage of 2x1500 MVA ICTs on each section, with 400 kV bus sectionaliser kept open)	8.	Minimum Short circuit level (MVA) at 400 kV KPS2 (both rectifier and inverter operation)	Sec-I: 25600 MVA and Sec-II: 19800 MVA (with IBR)# Sec-I: 17600 MVA and Sec-II: 13800 MVA (without IBR)# (Considering outage of 2x1500 MVA ICTs on each section, with 400 kV bus sectionaliser kept open)
		9.	Minimum Short circuit level (MVA) at 400 kV Nagpur (both rectifier and inverter operation)	18000MVA (Considering outage of 2x1500MVA ICTs, with 400kV bus sectionaliser kept closed)	9.	Minimum Short circuit level (MVA) at 400 kV Nagpur (both rectifier and inverter operation))	18000 MVA# (Considering outage of 2x1500 MVA ICTs, with 400 kV bus sectionaliser kept closed) <u>Sec-I: 12700 MVA# and Sec-II: 12700 MVA#</u> <u>(Considering outage of 1x1500 MVA ICT on each section, with 400 kV bus sectionaliser kept open)^</u>
	
		11.	Reverse power rating	100% of rated Forward direction power transfer rating (with 1.33 pu overload for 5 second only).	11.	Reverse power rating	100% of rated Forward direction power transfer <u>rating</u> [§] (with 1.33 pu overload for 5 second
	
		*TSP can provide integrated Control and Protection system as well, meeting functional requirements.					

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		<p>only).</p> <p>.. ...</p> <p>*TSP may provide integrated Control and Protection system as well, meeting functional requirements.</p> <p><u>\$ The power reversal in HVDC links shall be possible from the maximum active power transmission capacity from KPS2 HVDC to Nagpur HVDC to the maximum active power transmission capacity from Nagpur HVDC to KPS2 HVDC within 60 minutes. HVDC System shall be capable of at least three Power reversals in every 24 hours.</u></p> <p><u>#The values of short circuit level are based on available network topology and generated parameters for various network elements.</u></p> <p><u>^400 kV Bus sectionalizer at Nagpur end shall remain normally closed. However, the System shall be designed in such a way that it is possible to transmit full rated power (including overload as per S.No.-10 of Table-1) even with 400 kV Bus sectionalizer open and considering outage of 1x1500 MVA ICT on each section at the Nagpur end.</u></p> <p>....</p>
2.	6. System Performance RFP & TSA	... The rated power transmission capacity shall be defined and guaranteed at Rectifier DC Bus and rated transmission voltage shall be defined at the rectifier DC bus.	... The rated power transmission capacity shall be defined and guaranteed at Rectifier DC Bus and rated transmission voltage shall be defined at the rectifier DC bus. <u>In the calculation of the power transmission capability, the most unfavourable combination of control and measurement tolerances shall be considered and without redundant cooling and thyristors. All components of the transmission system shall be rated to meet the requirements</u>

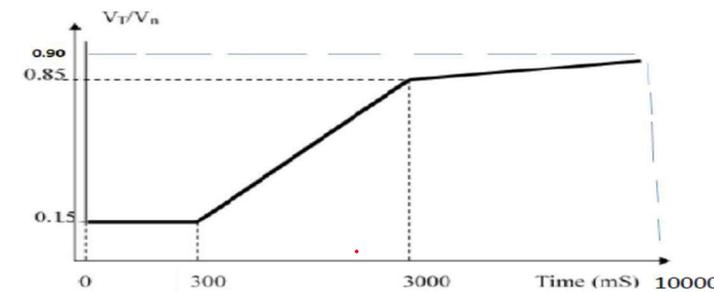
Sl No.	Clause No.	Existing Provision	New/Revised Provision
			<p><u>given in this section and other requirements specified elsewhere under these Specifications.</u></p> <p><u>HVDC system performance and rating requirements for high voltage equipment and other critical equipment shall be determined taking into account the extreme values of environmental and AC and DC system parameters as applicable for performance/ rating requirements given under these Specifications and manufacturing and measuring tolerances.</u></p>
3.	7. Overload Requirements RFP & TSA	<p>...</p> <p>(d) It may be noted that 1.2 pu and 1.1 pu overload ratings are for power compensation following loss of a healthy converter. However, the purpose of 33% overload is for system stability, power modulation and dynamic ride through of the system as a whole and can be initiated with the initial system conditions of 1.0 pu Bipolar or 1.1 pu overload Operation.</p>	<p>...</p> <p>(d) It may be noted that 1.2 p.u. and 1.1 p.u. overload ratings are for power compensation following loss of a healthy converter as well as for transmission of excess power during peak generation with all converters in service, up to 1.1 p.u. (i.e. 6600 MW) and 1.2 p.u. (i.e. 7200 MW). However, the purpose of 33% overload is for system stability, power modulation and dynamic ride through of the system as a whole and can be initiated with the initial system conditions of 1.0 p.u. Bipolar or 1.1 p.u. overload Operation.</p> <p><u>(e) For calculations, maximum line resistance shall be taken at a maximum conductor temperature of 85°C with minimum wind velocity and maximum solar radiation while for minimum line resistance the conductor temperature shall be taken as 0 °C.</u></p>
4.	11. System Studies RFP & TSA	<p>...</p> <p>(w) Interaction studies between HVDC and nearby Inverter Based Resources (IBR)</p> <p>...</p> <p>(aa) Studies of DC Current flowing through Windings of Converter Transformers</p> <p>(bb) Studies for the Control, Protection and Communication Systems</p> <p>The study reports shall include the following study results:</p> <p>(i) Dynamic Performance Study including the RE Resources near Converter Stations</p> <p>...</p>	<p>...</p> <p><u>(w) Interaction studies between this LCC HVDC and other HVDC stations including VSC based ± 500 kV, 2500 MW Converter near KPS-3, LCC based 2500 MW converter at Mundra terminal, LCC based 1500 MW converter at Chandrapur (near Nagpur), LCC based 1000 MW back-to-back converters at Chandrapur (near Nagpur), STATCOMs (planned/execution) which are electrically coupled nearby and other nearby Inverter Based Resources (IBR) and Inverter based Load.</u></p> <p>...</p> <p><u>(aa) Studies of DC Current flowing through Windings of Converter Transformers.</u></p> <p><u>(bb) AC line and other bays protection co-ordination studies</u></p> <p><u>(cc) DC over voltage studies</u></p>

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		<p><u>(cc)</u> Any other studies as deemed necessary by TSP ...</p>	<p><u>(dd) Station earthing</u> <u>(ee) LVRT, HVRT, harmonic resonance and other dynamic studies</u></p> <p>bb <u>(ff) Studies for the Control, Protection and Communication Systems</u> The study reports shall include the following study results: (i) Dynamic Performance Study (DPS) including the RE Resources near Converter Stations. <u>DPS studies shall be done with DPS model of Khavda VSC HVDC, DPS model of Khavda Pooling station and RE Park in vicinity.</u> ... (xi) Additional Control Study ... e) Supplementary modulation signals ...</p> <p><u>cc (gg) Any other studies as deemed necessary by TSP</u></p> <p><u>TSP shall carry out necessary studies for performance under this RfP considering the 400 kV Bus-sectionalizers at KPS-2 (S/s) and Nagpur (S/s) in both open and closed condition.</u></p> <p><u>The load flow and dynamic file shall be provided to the TSP in PSS/E 34 or newer version format. This will include maximum and minimum fault contribution from conventional generation and IBRs considering full power, reduced DC voltage power and other network scenarios which can lead to the highest possible dynamic overvoltage variations. Necessary Generic Models for IBRs or modelling assumptions shall also be provided for studies requiring the same. Conventional generator, lumped mass model and controller models in vicinity shall also be provided. For sharing User Defined Models (UDMs) TSP and Solution Providers will be required to abide with the statutory requirements of the UDM provider if required.</u> <u>In case of absence of detailed models of nearby inverters and 2500 MW VSC HVDC, the harmonic distortions shall be</u></p>

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			<p><u>considered as per the relevant CEA Regulations. The impedance of RE Park at the Pooling station PCC will be provided to the TSP. The rest of the network may be modelled by the harmonic impedance and the rating and performance studies shall be done accordingly. Harmonic impedance shall take into account all contingencies in base file, N-1, N-2 and other PSS/E scenarios for network for full power and reduced DC power.</u></p> <p>PSS/E files are provided based on the data available at the time of issuance of RfP.</p> <p>...</p>
5.	12. Digital Models RFP & TSA	<p>...The models shall be up to date with all the design features implemented in the Project.</p> <p>(a) PSCAD (b) PSS/E</p> <p>Data sharing requirements as per Procedure for First Time Charging/Energization (FTC) and Integration of New or Modified Power System Element of Grid Controller of India Ltd. (GRIDINDIA) shall also be done by the TSP. All the requisite data/reports/models including User defined models/documents as required as per the CEA/CTU/Grid India Standards/ Guidelines shall be provided by the TSP.</p>	<p>...The models shall be up to date with all the design features implemented in the Project.</p> <p>(a) PSCAD (b) PSS/E</p> <p><u>TSP shall provide both UDM and Generic model for RMS based stability model (in PSS/E V36 or above) and EMT (PSCAD v5 and above). All appropriate control features shall be modelled in the above models and necessary documentation on the theory and use of model should be provided. Further, a generic model, benchmarked to the extent possible to the UDM PSS/E and PSCAD model, shall also be furnished. Generic models can be shared by the CEA, CTU and Grid-India with the concerned stakeholders/external party(ies) e.g. STUs etc. on need basis. For User Defined model, confidentiality shall be maintained by the CEA, CTU and Grid-India. For PSCAD, User Defined model shall be provided by the TSP for which confidentiality shall be maintained by the CEA, CTU and Grid-India. Both UDM (PSCAD and PSS/E) and Generic model (PSSE) shall be provided by OEMs to CEA/CTU/GRID-INDIA without any NDA (Non-Disclosure Agreement).</u></p>

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			Data sharing requirements as per Procedure for First Time Charging/Energization (FTC) and Integration of New or Modified Power System Element of Grid Controller of India Ltd. (GRIDINDIA) shall also be done by the TSP. All the requisite data/reports/models including User defined models/documents as required as per the CEA/CTU/Grid India Standards/ Guidelines shall be provided by the TSP. <u>Data sharing format will be subject to the agreement or other statutory requirements mandated by HVDC OEMs, if required.</u>
6.	13. DC power circuit switching requirement RFP & TSA	... The DC power circuit arrangement shall provide at least the following functions: <u>The station layout shall provide safe access to all equipment for service and maintenance.</u> The DC power circuit arrangement shall provide at least the following functions: ...
7.	14. Insulation co-ordination RFP & TSA	(g) Temporary Overvoltages The converter valves shall be capable of continuing to operate under the temporary overvoltage conditions specified below, which could occur with the valves deblocked and also that the valves are capable of deblocking under the highest temporary over voltage conditions within 5 (five) cycles of the initiation of a fault or disturbance. Equipment shall be designed for the applicable short circuit ratio and overvoltage arising thereby. The converter Equipment shall be designed to withstand temporary over voltages corresponding to AC Side which are not less than 1.4 times 400 kV at converter stations with the converter blocked. ... The converter equipment shall be rated for continued operation under the maximum over voltage conditions to be defined by the TSP taking into consideration the dynamic over voltage profiles as determined by the design studies to be performed by the TSP.	(g) Temporary Over voltages The converter valves shall be capable of continuing to operate under the temporary overvoltage conditions specified below, which could occur with the valves de-blocked and also that the valves are capable of de-blocking under the highest temporary over voltage conditions within 5 (five) cycles of the initiation of a fault or disturbance. Equipment shall be designed for the applicable short circuit ratio and overvoltage arising thereby. The converter Equipment shall be designed to withstand temporary over voltages corresponding to AC Side which are not less than 1.5 times 400 kV at converter stations with the converter blocked. ... The converter equipment shall be rated for continued operation under the maximum over voltage conditions to be defined by the TSP taking into consideration the dynamic over voltage profiles as determined by the design studies to be performed by the TSP. Irrespective of the over voltage profile derived by the TSP, the equipment shall be rated to withstand an over voltage according to above figures following de-

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		<p>Irrespective of the over voltage profile derived by the TSP, the equipment shall be rated to withstand an over voltage according to above figures following deblocking. ...</p> <p>Any switching equipment within the scope of supply of the TSP which may be called upon to operate at this voltage in either a main or backup role shall have the appropriate capability.</p>	<p>blocking.</p> <p><u>DC withstand voltage design of equipment shall take due consideration of the temporary voltage stresses that the respective equipment may be exposed to based on studies of different disturbances as applicable.</u></p> <p>Any switching equipment within the scope of supply of the TSP which may be called upon to operate at this voltage in either a main or backup role shall have the appropriate capability.</p> <p><u>HVRT Strategy</u> <u>The HVDC Station shall enter into HVRT mode (exit from continuous operating region) when the Voltage at AC bus i.e. 400 kV side (RMS) is above 1.1 p.u. due to faults/control actions/or any other cause.</u></p> <p><u>The HVDC Station shall remain connected to the grid when voltage at the inter-connection point (AC bus), on any or all phases (symmetrical or asymmetrical overvoltage conditions) rises above the specified values given below for specified time:</u></p> <table border="1" data-bbox="1220 1089 2043 1425"> <thead> <tr> <th data-bbox="1220 1089 1493 1198"><u>Over voltage (pu#)</u></th> <th data-bbox="1493 1089 2043 1198"><u>Minimum time to remain connected at POI</u></th> </tr> </thead> <tbody> <tr> <td data-bbox="1220 1198 1493 1263"><u>V > 1.50</u></td> <td data-bbox="1493 1198 2043 1263"><u>Instantaneous trip</u></td> </tr> <tr> <td data-bbox="1220 1263 1493 1320"><u>1.50 ≥ V > 1.30</u></td> <td data-bbox="1493 1263 2043 1320"><u>100 ms</u></td> </tr> <tr> <td data-bbox="1220 1320 1493 1377"><u>1.30 ≥ V > 1.10</u></td> <td data-bbox="1493 1320 2043 1377"><u>10 sec</u></td> </tr> <tr> <td data-bbox="1220 1377 1493 1425"><u>V ≤ 1.10</u></td> <td data-bbox="1493 1377 2043 1425"><u>Continuous</u></td> </tr> </tbody> </table>	<u>Over voltage (pu#)</u>	<u>Minimum time to remain connected at POI</u>	<u>V > 1.50</u>	<u>Instantaneous trip</u>	<u>1.50 ≥ V > 1.30</u>	<u>100 ms</u>	<u>1.30 ≥ V > 1.10</u>	<u>10 sec</u>	<u>V ≤ 1.10</u>	<u>Continuous</u>
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			<p><u># 1pu = 400 kV (3 phase RMS voltage at POI)</u></p> <p><u>LVRT Strategy</u></p> <p><u>The HVDC Station shall enter into LVRT mode (exit from the continuous operating region) when the Voltage at AC bus i.e. 400 kV side (RMS) is below 0.9 p.u. due to faults/control actions/or any other cause.</u></p> <p><u>The HVDC Station must remain connected to the grid when voltage at the interconnection point (AC bus), on any one, two or all phases (symmetrical or asymmetrical overvoltage conditions) dips up to the level depicted by the thick lines in the following curve:</u></p>  <p><u>1 p.u. = 400 kV (3 phase RMS voltage at POI)</u></p> <p><u>During LVRT mode, HVDC Station shall withstand all above low voltage conditions. Restoration of voltage shall be said to be achieved when the voltage at POI settles within +5% of pre fault voltage.</u></p>
8.	16 Dynamic	(a) The purpose of dynamic performance design is to determine the control parameters for HVDC system and to ensure that	(a) The purpose of dynamic performance design is to determine the control parameters for HVDC system and to ensure that the HVDC

S I N O.	Clause No.	Existing Provision	New/Revised Provision
	Performance RFP & TSA	<p>the HVDC system shall have smooth, stable and fast operation for both steady state and transient conditions without adversely affecting the connected AC grid.</p> <p>(b) ...</p>	<p>system shall have smooth, stable and fast operation for both steady state and transient conditions without adversely affecting the connected AC grid.</p> <p><u>The principal objectives of the design shall include:</u></p> <ul style="list-style-type: none"> (i) <u>Optimal response of HVDC controls following step change in ordered parameters like DC current, DC voltage, power, etc.</u> (ii) <u>Stable operation of the DC system following major disturbances.</u> (iii) <u>Stabilization of the AC system following major disturbances.</u> (iv) <u>Control of temporary over-voltages and avoidance of self-excitation of the generators.</u> (v) <u>Control of frequency following quasi-static (slow) and fast changes in AC system load / generation at the rectifiers and/ or inverter ends.</u> (vi) <u>Control of power levels depending on the system configuration. Such a control may require AC line load control (ACLLC) and Run Back control features.</u> <p>(b) ...</p>
9.	19. Converter Station AC Yard, Transformer yard and valve hall RFP & TSA	<p>(b) Dynamic over voltage limiter devices Converters connected to relatively weak AC systems may cause dynamic over voltages (DOVs) during load rejection / disturbance. The DOV limiter shall consist of parallel arrester elements connected phase to phase or phase to ground and designed to absorb the desired amount of energy during a system disturbance. The DOV limiter shall be coordinated with recovery of DC system following a disturbance. The requirements of surge arresters shall be based on the insulation co-ordination study in line with relevant standards. The arresters used shall be metal oxide (ZnO) type conforming to relevant standards.</p> <p>(c) AC harmonic filters and shunt compensation</p>	<p>(b) Dynamic over voltage limiter devices The converters connected to relatively weak AC systems may cause dynamic over voltages (DOVs) during load rejection / disturbance. The DOV limiter shall consist of parallel arrester elements connected phase to phase or phase to ground and designed to absorb the desired amount of energy during a system disturbance <u>to protect the HVDC system during the HVRT period.</u> The DOV limiter shall be coordinated with recovery of DC system following a disturbance. The requirements of surge arresters shall be based on the insulation co-ordination study in line with relevant standards. The arresters used shall be metal oxide (ZnO) type conforming to relevant standards.</p> <p>(c) AC harmonic filters and shunt compensation</p>

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		<p>(iv) Performance Requirement ... Short-time and transient conditions as well as operation with discontinuous DC current must be fully taken into account.</p> <p>(iv)(a) System Contribution ...</p>	<p>(iv) Performance Requirement ... Short-time and transient conditions as well as operation with discontinuous DC current must be fully taken into account. <u>The system shall also meet the reactive power exchange limits on both the AC side.</u></p> <p>(iv)(a) System Contribution ...</p> <p>(v) <u>Power Monitoring Device and Power Quality Recorder: The TSP shall provide one number of Power Monitoring Device and Power Quality Recorder as per IEC 61000-4-30 class-A at suitable location (400 kV AC Bus) at each end of KPS2 and Nagpur Substation for acquisition, visualization, evaluation and transmission of electrical measured variables such as alternating current, alternating voltage, frequency, power, harmonics etc. The acquisition and processing of measured variables and events shall be performed according to the power quality measurement standard IEC 61000-4-30 class-A compatible with IEC 61850 protocol.</u></p>
10	21. Converter Station DC Outdoor Yard RFP & TSA	<p>21. Converter Station DC Outdoor Yard</p> <p>(a) The DC yard shall comprise of equipment such as HVDC bushings, smoothing reactors, DC filters, DC current and voltage measuring instruments and switchgear, surge arrester, insulators, clamps and connectors.</p> <p>(b) The specific creepage distance (corresponding to highest DC voltage) for DC yard and other areas shall be maintained as follows: <u>Table 6</u></p>	<p>21. Converter Station DC Yard</p> <p>(a) The DC yard shall comprise of equipment such as HVDC bushings, smoothing reactors, DC filters, DC current and voltage measuring instruments and switchgear, surge arrester, insulators, clamps and connectors. <u>DC Yard at Nagpur end shall be outdoor yard. However, at KPS-2 the DC yard shall be indoor with following specifications.</u></p> <p>(i) <u>The indoor DC yard building shall be constructed adjacent to the valve hall. Suitable arrangements shall be made for O&M and replacement of the equipment. The floor of the indoor DC yard shall have a heavy-duty floor slab suitable for movement of heavy equipment.</u></p> <p>(ii) <u>The indoor DC yard shall be a ventilated hall containing DC yard equipment connected to ±800 kV HV pole bus</u></p>

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		Insulator type	Under light and medium pollution	Under heavy and very heavy pollution	<u>such as smoothing reactors, high speed parallel/ de-parallel switch, line isolator, DC Current Transducer (DCCT), voltage divider, Line Fault Locator (LFL), DC filters (at least including HV capacitors) etc.</u>																				
		Indoor porcelain or composite insulators for valve hall (other than valves) and indoor smoothing reactor area (if any)	20 mm/ kV		(b) The specific creepage distance (corresponding to highest DC voltage) for DC yard and other areas shall at least be maintained as follows:																				
		Thyristor Valves	14 mm/ kV		Table 6																				
		Outdoor porcelain insulators or bushings with RTV coating	50 mm/ kV	60 mm/ kV	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th data-bbox="1209 586 1686 737">Insulator type</th> <th data-bbox="1692 586 1864 737">Under light and medium pollution</th> <th data-bbox="1871 586 2043 737">Under heavy and very heavy pollution</th> </tr> </thead> <tbody> <tr> <td data-bbox="1209 742 1686 888">Indoor porcelain or composite insulators for valve hall (other than valves) and indoor smoothing reactor area (if any)</td> <td colspan="2" data-bbox="1692 742 2043 888">20 mm/ kV</td> </tr> <tr> <td data-bbox="1209 893 1686 958"><u>Indoor DC Yard (other than smoothing reactor)</u></td> <td colspan="2" data-bbox="1692 893 2043 958"><u>30 mm/ kV</u></td> </tr> <tr> <td data-bbox="1209 963 1686 990">Thyristor Valves</td> <td colspan="2" data-bbox="1692 963 2043 990">14 mm/ kV</td> </tr> <tr> <td data-bbox="1209 995 1686 1141">Outdoor porcelain insulators or bushings with room temperature vulcanizing (RTV) coating</td> <td data-bbox="1692 995 1864 1141">50 mm/ kV</td> <td data-bbox="1871 995 2043 1141">60 mm/ kV</td> </tr> <tr> <td data-bbox="1209 1146 1686 1222">Outdoor composite insulators or bushings</td> <td colspan="2" data-bbox="1692 1146 2043 1222">50 mm/ kV</td> </tr> </tbody> </table>			Insulator type	Under light and medium pollution	Under heavy and very heavy pollution	Indoor porcelain or composite insulators for valve hall (other than valves) and indoor smoothing reactor area (if any)	20 mm/ kV		<u>Indoor DC Yard (other than smoothing reactor)</u>	<u>30 mm/ kV</u>		Thyristor Valves	14 mm/ kV		Outdoor porcelain insulators or bushings with room temperature vulcanizing (RTV) coating	50 mm/ kV	60 mm/ kV	Outdoor composite insulators or bushings	50 mm/ kV	
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		Outdoor composite insulators or bushings	50 mm/ kV		<p data-bbox="317 769 1129 1057"><i>Note: Specific creepage distances less than 50 mm/ kV but not less than 45mm/ kV can be accepted for outdoor silicone rubber bushings due to manufacturing limitations and for HVDC equipment requiring necessary internal/ external insulation co-ordination. However, specific creepage distance less than 50 mm/ kV and flash distance less than 12 mm/ kV shall not be acceptable for outdoor jointed bushing.</i></p> <p data-bbox="317 1101 1129 1166">The base <i>voltage</i> applicable for calculation of valve arrester creepage distance shall be:</p> $U_{creepage} = \sqrt{\left(\frac{1}{3} + \frac{\sqrt{3}}{8\pi}\right) * CCOV}$ <p data-bbox="317 1278 1083 1305">Where, CCOV: Crest value of Continuous Operating Voltage</p> <p data-bbox="317 1326 386 1354">...</p> <p data-bbox="1167 1261 2053 1476"><i>Note: Specific creepage distances less than 50 mm/ kV but not less than 45 mm/ kV can be accepted for outdoor silicone rubber bushings due to manufacturing limitations and for HVDC equipment requiring necessary internal/ external insulation co-ordination. However, specific creepage distance less than 50 mm/ kV and flash-distance less than 12 mm/ kV shall not</i></p>																				

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			<p><i>be acceptable for outdoor jointed bushing.</i></p> <p>The base <i>voltage</i> applicable for calculation of valve arrester creepage distance shall be:</p> $U_{creepage} = \sqrt{\left(\frac{1}{3} + \frac{\sqrt{3}}{8\pi}\right) * CCOV}$ <p>Where, CCOV: Crest value of Continuous Operating Voltage</p> <p>...</p>
11	23. Control and Protection System RFP & TSA	<p>It shall be demonstrated that the HVDC...</p> <p>...</p> <p>The performance of the integrated DC and AC systems shall also be demonstrated using an EMT-type program (such as PSCAD) in order to validate the system performance requirements.</p> <p>...</p> <p>(a) Control System:</p> <p>...</p> <p>(iv) The HVDC Station/Bipole shall have control features (as and when established by system design) including but not limited to the following:</p> <p>...</p> <p>(7) AC system stability function, such as power swing damping function</p> <p>...</p> <p>(b) Protection System The protection system shall be designed in Main-I and Main-II set up.</p> <p>(i) HVDC system protection shall consist of two parts:</p> <p>...</p> <p>(B) DC side protection DC side protection shall cover the zones consisting of the valve hall, DC switchyard including smoothing reactor and DC filters, DC line, and DMR line. The protection equipment</p>	<p>It shall be demonstrated that the HVDC...</p> <p>...</p> <p>The performance of the integrated DC and AC systems shall also be demonstrated using an EMT-type program (such as PSCAD) in order to validate the system performance requirements. <u>In the DPS program, all the HVDC protections shall be modelled. All feeders in the ac converter bus should have the required protections modelled for DPS studies with network equivalent. DPS studies shall be done with DPS model of Khavda VSC HVDC, DPS model of Khavda Pooling station and RE Park in vicinity. DPS models shall be provided for the VSC HVDC and Khavda Pooling station including RE park shall be provided to TSP.</u></p> <p>...</p> <p>(a) Control System:</p> <p>...</p> <p>(iv) The HVDC Station/Bipole shall have control features (as and when established by system design) including but not limited to the following:</p> <p>...</p> <p>(7) AC system stability function, such as power swing damping function</p> <p><u>(8) RE Park Sub synchronous control interaction, Temporary and Transient over-voltages, harmonic interactions, stability, HVRT, LVRT etc. studies,</u></p> <p><u>(9) Interaction studies among various HVDC links and STATCOMs (planned/ execution) which are electrically</u></p>

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		<p>shall be designed to be fail safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures. 'Main-I and Main-II' or 'Main and Standby' protection philosophy shall be adopted for HVDC equipment and system.</p> <p>...</p> <p>(iii) Protection system shall have two redundant systems with following protections (Some protection can be combined).</p> <p>a) Converter differential protection b) DC over current/under current protection c) DC bus differential protection d) AC conductor ground fault protection ...</p> <p>m) Thyristor failure monitoring</p>	<p><u>coupled nearby but not limited to e.g. VSC based ±500 kV, 2500 MW converter near KPS-3; LCC based 2500 MW converter at Mundra (about 180 km from Khavda) terminal, LCC based 1500 MW converter at Chandrapur (near Nagpur), LCC based 1000 MW back-to-back converters at Chandrapur (near Nagpur), STATCOMS as per following table:</u></p> <table border="1" data-bbox="1220 509 2028 850"> <thead> <tr> <th data-bbox="1220 509 1310 581"><u>Sr. No.</u></th> <th data-bbox="1316 509 1633 581"><u>Capacity of STATCOM</u></th> <th data-bbox="1640 509 2028 581"><u>Name of Substation</u></th> </tr> </thead> <tbody> <tr> <td data-bbox="1220 581 1310 621"><u>1</u></td> <td data-bbox="1316 581 1633 621"><u>±300 MVar</u></td> <td data-bbox="1640 581 2028 621"><u>KPS-1 (Section-I)</u></td> </tr> <tr> <td data-bbox="1220 621 1310 662"><u>2</u></td> <td data-bbox="1316 621 1633 662"><u>±300 MVar</u></td> <td data-bbox="1640 621 2028 662"><u>KPS-1 (Section-II)</u></td> </tr> <tr> <td data-bbox="1220 662 1310 703"><u>3</u></td> <td data-bbox="1316 662 1633 703"><u>±300 MVar</u></td> <td data-bbox="1640 662 2028 703"><u>KPS-3 (Section-I)</u></td> </tr> <tr> <td data-bbox="1220 703 1310 743"><u>4</u></td> <td data-bbox="1316 703 1633 743"><u>±300 MVar</u></td> <td data-bbox="1640 703 2028 743"><u>KPS-3 (Section-II)</u></td> </tr> <tr> <td data-bbox="1220 743 1310 784"><u>5</u></td> <td data-bbox="1316 743 1633 784"><u>±200 MVar</u></td> <td data-bbox="1640 743 2028 784"><u>Boisar-II (Section-I)</u></td> </tr> <tr> <td data-bbox="1220 784 1310 824"><u>6</u></td> <td data-bbox="1316 784 1633 824"><u>±200 MVar</u></td> <td data-bbox="1640 784 2028 824"><u>Boisar-II (Section-II)</u></td> </tr> <tr> <td data-bbox="1220 824 1310 850"><u>7</u></td> <td data-bbox="1316 824 1633 850"><u>±300 MVar</u></td> <td data-bbox="1640 824 2028 850"><u>Navsari (New)</u></td> </tr> </tbody> </table> <p>(10) <u>The TSP shall study all interaction aspects between these converter stations, STATCOMs and devise control strategies to ensure that no adverse interaction takes place among the above stations during steady state and fault recovery. Various fault cases for the purpose of this study shall be finalized by TSP during detailed engineering.</u></p> <p>(11) <u>The HVDC system shall conform to the performance requirements specified herein. It shall be designed to optimally co-ordinate all aspects of its controls to ensure safe and reliable operation without adversely affecting the connected AC system and shall assist the latter following disturbances. The performance requirements shall be met under all specified ambient conditions, modes of operation, AC system conditions and other parameters as given under these specifications.</u></p>	<u>Sr. No.</u>	<u>Capacity of STATCOM</u>	<u>Name of Substation</u>	<u>1</u>	<u>±300 MVar</u>	<u>KPS-1 (Section-I)</u>	<u>2</u>	<u>±300 MVar</u>	<u>KPS-1 (Section-II)</u>	<u>3</u>	<u>±300 MVar</u>	<u>KPS-3 (Section-I)</u>	<u>4</u>	<u>±300 MVar</u>	<u>KPS-3 (Section-II)</u>	<u>5</u>	<u>±200 MVar</u>	<u>Boisar-II (Section-I)</u>	<u>6</u>	<u>±200 MVar</u>	<u>Boisar-II (Section-II)</u>	<u>7</u>	<u>±300 MVar</u>	<u>Navsari (New)</u>
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			<p>Any other Controller as deemed required for stable HVDC system operation with connected AC network</p> <p>...</p> <p>(b) Protection System The protection system shall be designed in Main-I and Main-II set up.</p> <p>(i) HVDC system protection shall consist of two parts:</p> <p>...</p> <p>(B) DC side protection DC side protection shall cover the zones consisting of the valve hall; DC switchyard including smoothing reactor and DC filters; DC line and DMR line. The protection equipment shall be designed to be fail safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures. 'Main-I and Main-II' or 'Main and Standby' protection philosophy shall be adopted for HVDC equipment and system.</p> <p>...</p> <p>(iv) Protection system shall have two redundant systems with following protections (Some protection can be combined).</p> <p>a) Converter differential protection, <u>Converter protection</u></p> <p>b) <u>AC</u>, DC over current/ under current protection</p> <p>c) <u>AC</u>, DC bus differential protection</p> <p>d) AC conductor ground fault protection</p> <p>...</p> <p>...</p> <p>m) Thyristor failure monitoring</p> <p><u>n) AC overload protection</u></p> <p><u>o) DMR line monitoring and protection</u></p> <p><u>p) Sub Synchronous Torsional Interaction (SSTI) Protection (corresponding to synchronously run Power Plants)</u></p> <p><u>q) Sub Synchronous Control Interaction Protection (corresponding to RE plants)</u></p> <p>etc.</p>

Sl No.	Clause No.	Existing Provision	New/Revised Provision
12	23 Control and Protection System RFP & TSA	New Clause	<p><u>(c) A control and protection replica hardware (without redundancy) along with simulator shall be implemented for ±800 kV, 6000 MW KPS2- Nagpur HVDC System. The software and hardware design philosophy of control and protection replica shall be based on the actual design of ± 800 kV, 6000 MW KPS2-Nagpur HVDC LCC HVDC system. However, it shall be possible to reconfigure and change parameters in the controllers. The supply shall also include simulator interface panel, station HMI, Transient Fault Recorder, Station GPS clock, network equipment, Uninterrupted Power Supply (UPS) system, communication cables, cable trays/racks and other associated accessories.</u></p> <p><u>The details are mentioned in Appendix-C.6.</u></p>
13	48. Performance Guarantee for Converter Station (excluding HVDC line) RFP & TSA	<p>a) HVDC Station losses: The Guaranteed losses of HVDC converter stations shall include the no load loss and equivalent load loss. The equivalent load loss is the sum of load losses at specific loadings multiplied by weightage factors as per expected loading cycle. The Guaranteed losses shall be verified as per IEC 61803.</p> <p>b) No load loss shall be guaranteed corresponding to converter transformer set at principal tap with nominal AC system voltage and nominal frequency. Also refer maximum guaranteed loss figures in table below:</p> <p>c) The system shall meet various harmonic performance parameters on both AC side and DC side.</p> <p>d) Design targets for HVDC station Reliability and Availability^{^^} and station guaranteed losses[^] (per Bipole of 3000 MW):</p> <p style="text-align: center;">Table 10</p>	<p>a) HVDC Station losses: The Guaranteed losses of HVDC converter stations shall include the no load loss and equivalent load loss. The equivalent load loss is the sum of load losses at specific loadings multiplied by weightage factors as per expected loading cycle. The Guaranteed losses shall be verified as per IEC 61803. <u>The above losses shall be guaranteed at nominal DC voltage (± 800 kV at rectifier end) and nominal AC system Voltage (400 kV, 50 Hz) at ambient temperature of 40 deg C and relative humidity of 50%.</u></p> <p>b) No load loss shall be guaranteed corresponding to converter transformer set at principal tap## with nominal AC system voltage and nominal frequency. Also refer maximum guaranteed loss figures in table below:</p> <p>c) The system shall meet various harmonic performance parameters on both AC side and DC side <u>as well as the reactive power exchange limits on AC side as per these specifications while calculating the guaranteed losses.</u></p> <p>d) Design targets for HVDC station Reliability and Availability^{^^} and</p>

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		<table border="1"> <tr> <td data-bbox="367 284 430 464">1</td> <td data-bbox="443 284 789 464">Overall Energy availability of HVDC scheme (a) Overall Performance (b) Excluding transformer</td> <td data-bbox="802 284 1064 464">Not less than 97% Not less than 98%</td> </tr> <tr> <td data-bbox="367 472 430 537">2</td> <td data-bbox="443 472 789 537">Forced Energy Unavailability (FEU)</td> <td data-bbox="802 472 1064 537">Not more than 0.6%</td> </tr> <tr> <td data-bbox="367 545 430 610">3</td> <td data-bbox="443 545 789 610">Schedule Energy Unavailability (SEU)</td> <td data-bbox="802 545 1064 610">Not more than 1%</td> </tr> <tr> <td data-bbox="367 618 430 764">4</td> <td data-bbox="443 618 789 764">Single Pole outage per pole per station per year</td> <td data-bbox="802 618 1064 764">Not more than 8 (with average outage duration of 7.5 hours)</td> </tr> <tr> <td data-bbox="367 773 430 919">5</td> <td data-bbox="443 773 789 919">Bipole outage per station per year</td> <td data-bbox="802 773 1064 919">Not more than 0.2 (with average outage duration of 8 hours)</td> </tr> <tr> <td data-bbox="367 927 430 992">6</td> <td data-bbox="443 927 789 992">No-load losses (kW)</td> <td data-bbox="802 927 1064 992">0.2 % of Bipole Rating</td> </tr> <tr> <td data-bbox="367 1000 430 1065">7</td> <td data-bbox="443 1000 789 1065">Equivalent load loss (kW)*</td> <td data-bbox="802 1000 1064 1065">0.7% of Bipole Rating</td> </tr> </table> <p data-bbox="359 1105 1125 1203">* Equivalent load loss= Load loss at 1000 MW in kW*0.4 + Load loss at 1500 MW in kW * 0.16 + Load loss at 2500 MW in kW * 0.16 + Load loss at 3000 MW in kW * 0.28).</p> <p data-bbox="359 1252 1146 1317">^ - These loss figures are per bipole of 3000 MW for both the terminal stations</p> <p data-bbox="359 1325 1146 1390">^^The details for calculating Availability are mentioned in 'Appendix C.4'.</p> <p data-bbox="323 1398 1125 1463">For the loss guarantee stated above, following equipment/systems shall be considered</p> <p data-bbox="323 1471 359 1495">...</p>	1	Overall Energy availability of HVDC scheme (a) Overall Performance (b) Excluding transformer	Not less than 97% Not less than 98%	2	Forced Energy Unavailability (FEU)	Not more than 0.6%	3	Schedule Energy Unavailability (SEU)	Not more than 1%	4	Single Pole outage per pole per station per year	Not more than 8 (with average outage duration of 7.5 hours)	5	Bipole outage per station per year	Not more than 0.2 (with average outage duration of 8 hours)	6	No-load losses (kW)	0.2 % of Bipole Rating	7	Equivalent load loss (kW)*	0.7% of Bipole Rating	<p data-bbox="1230 245 1566 277">station guaranteed losses[^]</p> <p data-bbox="1608 318 1724 350" style="text-align: center;">Table 10</p> <table border="1"> <tr> <td data-bbox="1220 350 1283 537">1</td> <td data-bbox="1295 350 1629 537">Overall Energy availability of HVDC scheme per Bipole of 3000 MW (a) Overall Performance (b) Excluding transformer</td> <td data-bbox="1642 350 1923 537">Not less than 97% Not less than 98%</td> </tr> <tr> <td data-bbox="1220 545 1283 651">2</td> <td data-bbox="1295 545 1629 651">Forced Energy Unavailability (FEU) per Bipole of 3000 MW</td> <td data-bbox="1642 545 1923 651">Not more than 0.6%</td> </tr> <tr> <td data-bbox="1220 659 1283 764">3</td> <td data-bbox="1295 659 1629 764">Schedule Energy Unavailability (SEU) per Bipole of 3000 MW</td> <td data-bbox="1642 659 1923 764">Not more than 1%</td> </tr> <tr> <td data-bbox="1220 773 1283 911">4</td> <td data-bbox="1295 773 1629 911">Single Pole outage per station per year</td> <td data-bbox="1642 773 1923 911">Not more than 8 (with average outage duration of 7.5 hours)</td> </tr> <tr> <td data-bbox="1220 919 1283 1057">5</td> <td data-bbox="1295 919 1629 1057">Bipole outage per station per year</td> <td data-bbox="1642 919 1923 1057">Not more than 0.2 (with average outage duration of 8 hours)</td> </tr> <tr> <td data-bbox="1220 1065 1283 1138">6</td> <td data-bbox="1295 1065 1629 1138">No-load operation losses per Station</td> <td data-bbox="1642 1065 1923 1138">0.1 % of Bipole Rating</td> </tr> <tr> <td data-bbox="1220 1146 1283 1211">7</td> <td data-bbox="1295 1146 1629 1211">Equivalent load loss per station (kW)*</td> <td data-bbox="1642 1146 1923 1211">0.35 % of Bipole Rating</td> </tr> </table> <p data-bbox="1209 1252 2028 1349">* Equivalent load loss= Load loss at 1000 MW in kW*0.4 + Load loss at 1500 MW in kW * 0.16 + Load loss at 2500 MW in kW * 0.16 + Load loss at 3000 MW in kW * 0.28).</p> <p data-bbox="1209 1398 2028 1463">^ - These loss figures shall be calculated on per station and per bipole basis as per details mentioned in (a), (b), (c) and (d) of</p>	1	Overall Energy availability of HVDC scheme per Bipole of 3000 MW (a) Overall Performance (b) Excluding transformer	Not less than 97% Not less than 98%	2	Forced Energy Unavailability (FEU) per Bipole of 3000 MW	Not more than 0.6%	3	Schedule Energy Unavailability (SEU) per Bipole of 3000 MW	Not more than 1%	4	Single Pole outage per station per year	Not more than 8 (with average outage duration of 7.5 hours)	5	Bipole outage per station per year	Not more than 0.2 (with average outage duration of 8 hours)	6	No-load operation losses per Station	0.1 % of Bipole Rating	7	Equivalent load loss per station (kW)*	0.35 % of Bipole Rating
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			<p><u>this clause.</u> ^{^^}The details for calculating Availability are mentioned in <u>'Appendix C.4'</u>. <u>## Principal tap is the Tap Position of converter transformers when HVDC converters shall be delivering 1 p.u. power (6000 MW) at nominal DC voltage at rectifier (± 800 kV) keeping AC system voltage 400 kV, 50 Hz at 40 deg C ambient temperature and humidity of 50%.</u></p> <p>For the loss guarantee stated above, following equipment/systems shall be considered</p> <p>...</p>
14	<p>43. Operation During Reduced AC Voltage Condition</p> <p>RFP & TSA</p>	<p>...</p> <p>In addition to the requirements of operation under over voltage conditions specified in this specification, the converter equipment shall be able to continue operating without blocking of converters with AC bus voltage reduced to <u>30% of nominal</u> voltage during three phase faults, and to zero on one phase during single line to ground faults, <u>for a period of 1 second</u> followed by voltage recovery to 80%. The gate control units shall be able to trigger the thyristor valve as soon as the voltage recovers after the AC bus voltage has dropped <u>to zero for 1 second</u>. The converters shall continue to transmit power to the extent possible under the above reduced voltage conditions. The valve firing system as well as all the cooling equipment shall be rated for these conditions. The cooling system shall not trip during AC system faults.</p>	<p>...</p> <p>In addition to the requirements of operation under over voltage conditions specified in this specification, the converter equipment shall be able to continue operating without blocking of converters with AC bus voltage reduced to voltage <u>as depicted in the curve mentioned under LVRT Strategy at clause No.-14 "Insulation Coordination"</u> during three phase faults, and to zero on one phase during single line to ground faults followed by voltage recovery to 80%. The gate control units shall be able to trigger the thyristor valve as soon as the voltage recovers after the AC bus voltage has dropped. The converters shall continue to transmit power to the extent possible under the above reduced voltage conditions. The valve firing system as well as all the cooling equipment shall be rated for these conditions. The cooling system shall not trip during AC system faults.</p>
15	<p>15 Radio Interference (RI), Acoustic Noise (AN) and DC field</p>	<p>15. Radio Interference (RI), Acoustic Noise (AN) and DC field</p> <p>.....</p> <p>(d) For area with permanent access, the total calculated electric field at ground level shall not exceed 20 kV/m in the DC <u>outdoor</u> yard. For area with permanent access in DC <u>outdoor</u> yard,</p>	<p>15. Radio Interference (RI), Acoustic Noise (AN) and DC field</p> <p>.....</p> <p>(c) For area with permanent access, the total calculated electric field at ground level shall not exceed 20 kV/m <u>excluding space charge</u> in the DC yard.</p>

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	RFP & TSA	calculated Ion current density shall be less than 20 nA/m ² at ground level.	(d) For area with permanent access in DC yard, calculated Ion current density shall be less than 20 nA/m ² at ground level.																																																																																
16	Annexure C: Figure F.1 RFP & TSA	<p>Proposed Communication for Transmission System for Evacuation of Power from potential renewable energy zone in Khavda area of Gujarat under Phase-V (8 GW): Part A</p> <p>Note:* Number and location of repeater shall be finalized by TSP after survey Line lengths are indicative only shall be finalized after survey</p>	<p>Proposed Communication for Transmission System for Evacuation of Power from potential renewable energy zone in Khavda area of Gujarat under Phase-V (8 GW): Part A</p> <p>Note: 1. *Number and location of repeater shall be finalized by TSP after survey. 2. Line lengths are indicative only shall be finalized after survey. 3. Two no. of FOTE are to be provided at KPS2 HVDC & Nagpur HVDC Stations .</p>																																																																																
17	5. Environmental Data RFP & TSA	<p>The following environmental data shall be considered (Table-2):</p> <table border="1" data-bbox="346 1112 1081 1469"> <caption>Table 2</caption> <thead> <tr> <th>Sr. No</th> <th>System data</th> <th>Nagpur</th> <th>KPS2</th> </tr> </thead> <tbody> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>8.</td><td>Pollution level (IEC 60815)</td><td>Heavy</td><td>Heavy</td></tr> </tbody> </table>	Sr. No	System data	Nagpur	KPS2	8.	Pollution level (IEC 60815)	Heavy	Heavy	<p>The following environmental data shall be considered (Table-2):</p> <table border="1" data-bbox="1197 1112 1932 1469"> <caption>Table 2</caption> <thead> <tr> <th>Sr. No</th> <th>System data</th> <th>Nagpur</th> <th>KPS2</th> </tr> </thead> <tbody> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>...</td><td>...</td><td>..</td><td>...</td></tr> <tr><td>8.</td><td>Pollution level (IEC 60815)</td><td>Heavy</td><td>Heavy</td></tr> </tbody> </table>	Sr. No	System data	Nagpur	KPS2	8.	Pollution level (IEC 60815)	Heavy	Heavy
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Sl. No.	Clause No.	Existing Provision	New/Revised Provision																								
			<p><u>Note: The TSP shall ensure specific measures for protection against airborne salt at KPS-2 for all the equipment as well as ventilation system.</u></p>																								
18	7 (vi) RFP & TSA	<p>C.7 PLCC and PABX:</p> <p>(vi) PLCC equipment for all the transmission lines covered under the scheme shall be provided by TSP as per following configuration. PLCC to be provided for following lines under present scope:</p> <table border="1" data-bbox="344 591 1134 1073"> <thead> <tr> <th>Sl. No</th> <th>Line name</th> <th>PLCC configuration</th> </tr> </thead> <tbody> <tr> <td>1</td> <td><u>400 kV KPS2 – KPS2 (HVDC) 2xD/c Line</u></td> <td><u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u></td> </tr> <tr> <td>2</td> <td><u>400 kV Nagpur – Nagpur (HVDC) 2xD/c Line</u></td> <td><u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u></td> </tr> <tr> <td>3</td> <td>800 kV HVDC Bipole line between KPS2 (HVDC) and Nagpur (HVDC)</td> <td><u>1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends.</u></td> </tr> </tbody> </table> <p><u>Further, CVT and Wave trap for all line bays under present scope shall be provided by TSP where analog PLCC is required.</u></p>	Sl. No	Line name	PLCC configuration	1	<u>400 kV KPS2 – KPS2 (HVDC) 2xD/c Line</u>	<u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u>	2	<u>400 kV Nagpur – Nagpur (HVDC) 2xD/c Line</u>	<u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u>	3	800 kV HVDC Bipole line between KPS2 (HVDC) and Nagpur (HVDC)	<u>1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends.</u>	<p>C.7 PLCC and PABX:</p> <p>(vi) PLCC equipment for all the transmission lines covered under the scheme shall be provided by TSP as per following configuration. PLCC to be provided for following lines under present scope:</p> <table border="1" data-bbox="1215 591 2005 854"> <thead> <tr> <th>Sl. No</th> <th>Line name</th> <th>PLCC configuration</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>Deleted</td> <td>Deleted</td> </tr> <tr> <td>2</td> <td>Deleted</td> <td>Deleted</td> </tr> <tr> <td>1</td> <td>+800 kV HVDC Bipole line between KPS2 (HVDC) and Nagpur (HVDC)</td> <td><u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u></td> </tr> </tbody> </table> <p><u>In case of the above-mentioned line, wave traps are not required as both the paths for tele-protection are on point to point Optical Ground Wire.</u></p>	Sl. No	Line name	PLCC configuration	4	Deleted	Deleted	2	Deleted	Deleted	1	+800 kV HVDC Bipole line between KPS2 (HVDC) and Nagpur (HVDC)	<u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u>
Sl. No	Line name	PLCC configuration																									
1	<u>400 kV KPS2 – KPS2 (HVDC) 2xD/c Line</u>	<u>2 Sets of Digital Protection Coupler for each circuit at both ends.</u>																									
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19	SPECIFIC TECHNICAL REQUIREMENTS FOR HVDC TRANSMISSION LINE RFP & TSA	<p>A.7.0 The relevant conductor configuration shall be as follows: -</p> <p>i. Type of conductor: ACSR / AAAC / AL59</p> <p><u>Basic parameters for Transmission Line associated with HVDC Bipole link:</u></p>	<p>A.7.0 The relevant conductor configuration shall be as follows: -</p> <p>i. Type of conductor: ACSR / AAAC / AL59</p> <p><u>Basic parameters for Transmission Line associated with HVDC Bipole link:</u></p>																								

Sl. No.	Clause No.	Existing Provision					New/Revised Provision					
		Transmission line	ACSR Conductor	AAAC conductor based on 53% conductivity of AL Alloy (Size as per IEC-1089)	Minimum size of AL59 conductor based on 59% conductivity of AL Alloy (Size as per Swedish -SS-420814)	Sub-conductor Spacing	Transmission line	ACSR Conductor	AAAC conductor based on 53% conductivity of AL Alloy (Size as per IEC-1089)	Minimum size of AL59 conductor based on 59% conductivity of AL Alloy (Option 1)	Minimum size of AL59 conductor based on 59% conductivity of AL Alloy (Option 2)	Sub-conductor Spacing
		+800 kV HVDC transmission lines (hexa bundle configuration per pole)	Lapwing: Stranding 45/4.78 mm-Al + 7/3.18 mm-Steel; 38.22 mm diameter; 807.5 sq. mm, Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0358; Minimum UTS: 0.0358;	Stranding details: 61/4.38 mm, 39.5 mm diameter; 921 sq.mm Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0361; Minimum UTS:	Stranding details: 61/4.36 mm, 39.2 mm diameter; 910 sq.mm Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0326; Minimum UTS:	457 mm	+800 kV HVDC transmission lines (hexa bundle configuration per pole)	Lapwing: Stranding 45/4.78 mm-Al + 7/3.18 mm-Steel; 38.22 mm diameter; 807.5 sq. mm, Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0358; Minimum UTS: 188.0 kN	Stranding details: 61/4.38mm , 39.5 mm diameter; 921 sq.mm Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0361; Minimum UTS: 244.0 kN	Stranding details: 61/4.36 mm, 39.2 mm diameter; 910 sq.mm Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0326; Minimum UTS: 199.0 kN	Stranding details: 61/4.17 mm, 37.53 mm diameter; 833 sq.mm Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0356; Minimum UTS: 181.96 kN	457 mm

Sl No.	Clause No.	Existing Provision	New/Revised Provision
20	SPECIFIC TECHNICAL REQUIREMENTS FOR HVDC TRANSMISSION LINE RFP & TSA	<p>A.9.0 All electrical clearances including minimum live metal clearance, ground clearance and minimum mid span separation between earth wire and conductor shall be as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023 as amended from time to time and <u>IS:5613. Since these clearances</u> are not included in CEA Regulation/ Indian Standard, following values shall be considered:</p> <p><u>1) Minimum live metal clearances for +800 kV line:</u></p> <p>---</p> <p><u>b) Minimum ground clearance: 18 m</u></p> <p>....</p>	<p>A.9.0 All electrical clearances including minimum live metal clearance, ground clearance and minimum mid span separation between earth wire and conductor shall be as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023 as amended from time to time and <u>relevant Indian Standards. For the clearances</u> which are not included in CEA Regulation/ Indian Standard, following values shall be considered:</p> <p><u>1) Minimum live metal clearances for +800 kV line:</u></p> <p>---</p> <p><u>b) (i) Minimum ground clearance for AL 59 conductor (61/4.17 mm, 37.53 mm diameter): 19 m</u></p> <p><u>(ii) Minimum ground clearance for other conductors: 18 m</u></p>

TECHNICAL REQUIREMENTS FOR THE REPLICA-SIMULATOR SETUP

1. Scope

The document mentions technical requirements that should be considered by the TSP for the implementation of one real-time laboratory for the Factory System Test (FST), commissioning, operation, training and optimization of KPS2-Nagpur parallel bipole (Bipole 1 and Bipole 2) HVDC systems in a large AC Grid. Considering the strategic importance, complexity of controls and protection, operation and dynamic performance of the bipole system, the simulation facility shall include bipole replica – real time simulator setup.

It shall be in the scope of TSP to have ± 800 kV, 6000 MW KPS2-Nagpur Bipole control and protection replica hardware (without redundancy) for both bipoles along with simulator. The software and hardware design philosophy of control and protection replica shall be based on the design of ± 800 kV, 6000 MW KPS2-Nagpur HVDC Parallel Bipole system. However, the replica shall be reconfigurable by changing parameters in the controllers. . The scope shall also include to keep simulator interface panel, station HMI, Transient Fault Recorder, Station GPS clock, network equipment, Uninterrupted Power Supply (UPS) system, communication cables, cable trays/racks, tools and tackles, suitable furniture including operator desk, spares and other accessories required to implement KPS2-Nagpur Bipole control and protection system.

The Dynamic performance test (DPS)/ Factory System Test (FST) for ± 800 kV, 6000 MW KPS2-Nagpur HVDC system shall be carried out with simulator and the same simulator shall be kept by TSP. The simulator shall contain AC network modeled as both i) voltage sources behind short circuit impedance and ii) detailed AC equivalent network as specified in TS to carry out test cases with both options.

The spare cards/ modules including maintenance spares, communication cables etc. required for operation and maintenance of the replica system and simulator shall also be a part of supply. Minimum 10% spares shall be provided. The UPS provided for replica-simulator system shall have additional capacity of 10 kVA. The manufacturer of UPS shall have an operational authorized maintenance and support center in India at the time of award of the contract.

The TSP shall ensure support from OEM for KPS2-Nagpur Bipole control and protection replicas (Bipole 1 and Bipole 2) and simulator, for debugging the faults related to software and hardware and to provide software updates and hardware support for the useful life of the project..

The Replica and Simulator system shall be made available free of charge for conducting studies and tests proposed by CEA/CTUIL/Grid-India.

2. Main specifications of simulator for Real-Time Laboratory

The Simulators for Real-Time Laboratory must comply with the following specifications.

2.1.1 Real-Time Simulation Laboratory Capability

Considering the strategic importance, complexity of controls and protection, operation and

dynamic performance of the HVDC system, the simulation facility shall include a Large Scale Real-Time Simulator (LSRTS). The real-time simulation facility will enable the CEA/CTUIL/Grid India to conduct system planning, operation and engineering studies with hardware/software in the loop as needed at different stages of the project.

2.1.2 Specification of Real-Time Simulator

2.1.2.1 Simulation Capability

For the Dynamic performance test/ Factory System Test, the complete AC-system shall be represented by an equivalent network.

The simulator must be able to simultaneously simulate following:

- (i) The complete parallel bipole DC system (LCC) with all converters, DC and AC equipment, and AC/DC filter bank and other associated equipment that shall be delivered at each station of the KPS2-Nagpur HVDC system.
- (ii) The detailed model of each controller of the parallel bipole systems shall include all HVDC controllers, filter bank controllers.

The AC grid that will be connected to the HVDC system terminals with the following capabilities:

- (i) One equivalent AC system at each terminal of the HVDC system with the possibility to modify, short-circuit inductances, resonance conditions and damping, while the simulator is running.
- (ii) Detailed dynamic equivalent AC system model with at least 200 3-phase busses including a minimum of 100 transmission lines, 50 generators modeled in details with controllers, 75 (3-ph) transformers with saturation, 25 (3-ph) fixed-impedance loads and 25 dynamic loads, 20 (3-ph) arrestors, models of 5 HVDC, 10 SVCs, 20 STATCOMs and 10 TCSCs, 50 Inverter Based Resources (IBR) alongwith associated Power plant controllers (PPCs).

2.1.2.2 Input-Output Interface

The real-time simulator must also have all necessary digital input-output systems to interface with detailed replicas (the actual control and protection system for bipole) of all HVDC controllers that shall be supplied as part of the bipole project

2.2 Operating flexibility, modularity and re-configurability

2.2.1 Real-Time and Non-Real-Time Simulation

The real-time simulator must be able to operate in real-time simulation mode with IO interface and non-real-time simulator in non-real-time simulation mode using the same HVDC and EHVAC grid models. In non-real-time simulation mode, the simulator shall have the capability to execute simple and detailed models of HVDC, SVC and other FACTS controllers used for this project.

2.2.2 Minimum Simulation Time Step and Advanced Converter Models

The real-time simulator shall have the capability to simulate in real time with integration time step of not more than 50 microseconds for the entire - bipole system, AC reactive compensation equipment, converters, and HVDC simulation, in order to reduce the number of processors, the detailed AC system may have integration time step of 50 microseconds or less.

TSP shall seek Simulator suppliers to propose advanced switching algorithms and converter models to reach an effective switching/ firing resolution better than 10 microsecond for the slow variation of converter power as required for verifying the damping of SSR controller. The required time steps shall also be programmable. Controller shall specify any additional requirement to the Simulator supplier as necessary to meet their test objectives for the delivery of the bipole system.

2.2.3 Voltage Source Converter (VSC) Power Electronic System Simulation

Following generic models shall be supplied.

Digital simulators should be optimized for the simulation of VSC power electronic systems integrated with large power grids. Furthermore, the proposed simulator must be designed to handle models with several thousands of individually controlled IGBTs as applicable used to implement modern multi-level VSC converters.

The proposed simulator should also be able to simulate DC-AC and AC-DC three-phase power converter models built with fast power electronic devices (MOSFET, IGBT), typical of those used in micro-grids or distributed energy generation (concentrated solar cell, micro-gas turbine, photovoltaic generator, biomass, combined heat and power, battery storage system) should also be simulated accurately in real-time.

These very fast IGBT-based power electronic systems, which can influence the performance of conventional and modern protection systems, require much smaller simulation time step values than what can be achieved through the use of conventional DSP-based real-time simulators optimized for power grid simulation.

The TSP shall seek the Supplier to provide a fully flexible VSC sub-network whereby the user can freely configure the valve topology for Modular Multi level converter (minimum 512 full bridge sub-modules per valve), crowbar circuitry, filters, etc. and still achieve the required firing accuracy.

The TSP shall seek Supplier to demonstrate that MMC based voltage source converters have a continuously variable firing instant with a resolution of 3 microseconds or better. In addition, the TSP shall also seek Supplier to demonstrate capability to simulate in real-time a chain-link VSC converter model used in AC-DC-AC converters and FACTS with thousands of individually controlled switches similar to chain-link VSC systems offered by major suppliers.

2.3 Simple and Complex Controller Numerical Models

The Bipole HVDC systems shall consist of the following models.

2.3.1 Preliminary Models for Phasor -Type Simulation tools

These preliminary models shall include all basic control functions used for similar projects

and developed for transient stability software used by CEA/CTU/Grid India/TSP such as PSS/E.

2.3.2 Preliminary Models for Electro-Magnetic Transient type (EMT) Simulation Tools

These preliminary models shall include all typical control and protection functions used for similar projects and developed for EMT simulation tools such as PSCAD.

2.3.3 Detailed Models for Electro-Magnetic Transient (EMT) - type Simulation Tools

These models shall include all control and protection functions that will be used in controllers to be delivered for this project. TSP shall deliver several versions of these controllers developed at different phases of the project to enable CEA/CTU/Grid India/TSP to make simulation and analysis of the impact of the - bipole system on the remaining parts of the AC grid.

3 Preferred Technology Specifications

The following specifications in this clause are not mandatory but important optional items that will be used to select the real-time simulator technology fulfilling the mandatory specification items given in clause 2 above.

3.1 Off-the Shelf Software Technologies

The proposed simulator may take full advantage of off-the-shelf standard computer technology and commercially available software such as MATLAB, SIMULINK and SimPower Systems.

The proposed simulator should also be interfaced with PSCAD, the industry standard software for simulation and analysis of electromagnetic transients in power systems. Such non-real-time interface is very important for the model verification and to compare the results obtained from the real-time simulator with the results obtained from well-known non-real-time simulation tools accepted by the industry. The proposed simulator shall include interface software to facilitate the translation of the models used by PSCAD to the real-time simulator circuit data.

3.2 Scalability: Off-the-shelf multi-core Processor Board and Communication Fabric

The proposed digital real-time simulators may take full advantage of modern multi-core processors as soon as they become available from AMD or INTEL. Models should then be executed in - with minimum communication overhead by using on-chip and on-board shared-memory.

The real-time simulators may be implemented using very fast and low-latency commercial communication fabric to take advantage of communication technology evolution.

3.3 Advanced User-programmable FPGA-based I/O Systems and Co-Processors

3.3.1.1 User programmable FPGA chips and Development Software

The proposed simulator may include fast FPGA chips that can be programmed by users through graphical interface to implement specialized communication protocols, signal processing, control and protection systems.

3.3.1.2 Implementation of HVDC Controllers with time step below 1 micro-second

Users may have access to large FPGA chips so that TSP is able to implement their own models or models developed by universities or research centers.

Users may be able to implement fast PWM power converters and machine models with time step below 500 nanoseconds used in distributed energy systems and wind farms.

3.4 Operating Under Windows for offline Simulation

It may be possible to execute the simulator software on standard Windows multi-core computer for non-real-time simulation to execute the same model used for real-time simulation. The simulator software may take full advantage of all processors cores available on the workstation or on the computer server to execute the simulation as fast as possible. This feature would be useful to execute several optimization and Monte Carlo studies in non-real-time mode before executing real-time simulations with actual controllers.

3.5 Interface with Physical Modeling Tools

The simulator may be interfaced with physical modeling tools such as tools from the Mathworks, Dassault (Dymola), LMS (AMESim) and other tools specialized for mechanical, fluid dynamic and other systems usually integrated with electrical systems. This feature may become important for the simulation of distributed energy systems including wind farms, fuel cells and other equipment requiring complex model available in Simulink but not readily available with conventional real-time simulators.

3.6 Prototyping controller/protection systems

The proposed simulators may include optional single-processor prototyping systems to implement controller or protection system algorithms in real-time on separate computers. These prototyping systems should have all necessary input-output interfaces to enable its connection with the main simulators.

3.7 I/O Driver Development Software and Source Code

The simulator supplier shall supply the source code and documented application examples to enable TSP and its suppliers to develop and implement software interface with custom or third-party input-output interface boards used to communicate with other equipment or other real-time simulators. The source code example shall enable to implement fast and low latency communication interface with a maximum latency of 10 microseconds to transfer a data packet of 500 bytes in both directions.

4. Training on Control Replica

As a part of project, it shall be under the scope of TSP to provide the training for 15 man-months to the officials from CEA/CTU/Grid India regarding control/protection aspects of control replica / simulator in addition to its own manpower for the project..

5. Access to Control replica

The TSP shall provide full access to control replica/simulator to CEA/CTU/Grid India officials whenever required.