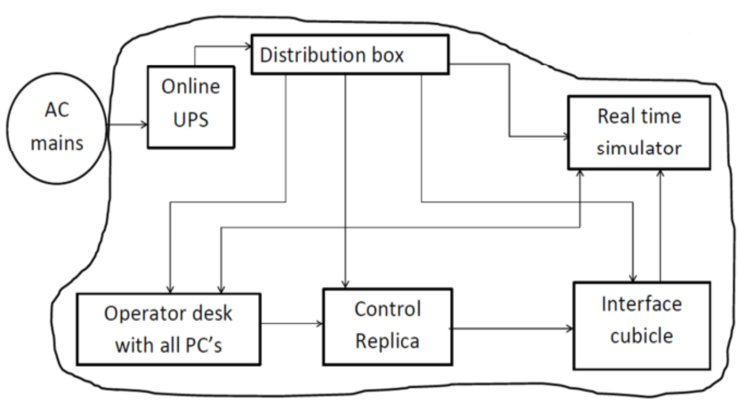
Amendment-02 dated 10.09.2024 to

RFP Documents for "*Transmission System for Evacuation of Power from potential renewable energy zone in Khavda area of Gujarat under Phase-V (8 GW): Part C*" through tariff based competitive bidding process.

Sl. No.	Clause No.	Existing Provision	New/Revised Provision
1.	51 (Page-191)	TSP shall supply complete VSC HVDC control and protection replica system without redundancy along with a real time simulator for both the poles based on project specification mentioned in this document. The software and hardware design philosophy of control and protection replica shall be based on the design of ± 500 kV, 2500 MW Khavda - South Olpad VSC HVDC system for the purpose of dynamic performance testing, commissioning, troubleshooting and optimization during operation and training. Figure-4 shows a general diagram of the scope of Control Replica.  Fig 4 : Scope of contractor for Control Replica As show in Figure-4, the supply shall include simulator interface panel, station HMI, Transient	**A control and protection replica hardware (without redundancy) along with simulator shall be implemented for ± 500 kV, 2500 MW KPS3-South Olpad Bipole. The software and hardware design philosophy of control and protection replica shall be based on actual design of ± 500 kV, 2500 MW KPS3-South Olpad HVDC VSC Bipole 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.** **The details are mentioned in Appendix-C.6.**

		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 the Control Replica. The dynamic performance test for 2500 MW Khavda – South Olpad HVDC VSC Bipole may be carried out with Control Replica, and the same shall be delivered to site after completion of site acceptance tests. The simulator shall contain AC network modelled as both voltage sources behind short circuit impedance and detailed AC equivalent network as provided to enable TSP to carry out test cases with both options.	

Appendix C.6

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 VSC DC 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.

The Dynamic Performance Test (DPS) /Factory System Test (FST) for 2500 MW KPS3-South Olpad HVDC Bipole shall be carried out with same simulator. 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 Technical Specification 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 KPS3-South Olpad HVDC Bipole control and protection replicas 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

The real-time simulation facility will enable 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 will be represented by an equivalent network.

The simulator must be able to simultaneously simulate following:

(i) The complete bipole DC system with all converters, DC and AC equipments, and AC/DC filter bank (as applicable) and other associated equipment that will be delivered at each station of the KPS3-South Olpad HVDC system.

(ii) The detailed model of each controller of the 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 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 will 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 suppliersto propose advanced switching algorithms and converter models to reach an effective switching/firing resolution better than 10 microsecond; for 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 Suppliers 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 SimPowerSystems.

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 of 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, training to TSP/CEA/CTU/Grid India officials regarding control/protection aspects of control replica / simulator shall be provided.

5. Access to Control replica

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