THIS MEMORANDUM OF UNDERSTANDING IS EXECUTED ON THIS 14th ***Day of March, 2022*** between, Department of Hydro and Renewable Energy, Indian Institute of Technology Roorkee (Hereinafter called the " HRED, IIT Roorkee ") which expression shall unless repugnant to the context herein include its administrators, successors, executors and permitted assigns of the First Party.

AND

Power System Operation Corporation Limited (A Government of India Enterprise), incorporated under the Companies Act, 1956, having its registered office at B-9,1st Floor, Qutab Institutional Area Katwaria Sarai, New Delhi-110016 (hereinafter referred to as "POSOCO") which expression shall unless repugnant to the context herein include its administrators, successors, executors and permitted assigns of the Second Part.

(HRED, IIT Roorkee and POSOCO are hereinafter individually referred to as the 'Party' and collectively as 'Parties')

OBJECTIVE OF MoU

Whereas both the parties have agreed that services provided by HRED, IIT Roorkee on Hydro and Renewable Energy etc shall be used by Power System Operators across India for better management of Indian Power System and for purposes of analysis.

Now therefore the HRED, IIT Roorkee and the POSOCO have intended, agreed and consented to the following terms and deeds in pursuance of a common intent.

1. **FIELD OF CO-OPERATION**

a) **Studying the Challenges and Benefits of Synchronous Condenser Mode of Operation under High Variable Renewable Energy Integration.**

Using classical transient stability analysis in PSSE, electromagnetic transient (EMT) analysis in PSCAD, and hybrid transient-EMT simulations using PSSE-PSCAD co-simulations HRED, IIT Roorkee will identify:

i) The regions in India where synchronous condensers are likely to be most beneficial.
ii) The renewable penetration levels at which synchronous condenser mode of operation will become critical to ensuring grid stability.
iii) The configurations in which synchronous condensers will prove most beneficial (e.g., stand-alone units, co-located with inverter-based resources (IBRs), with flywheels for additional inertia as used in Southern Australia).
iv) Challenges posed by synchronous condensers to grid stability (e.g., susceptibility to inter and intra-area oscillations such as those experienced in the pan-handle region of the Electric Reliability Council of Texas (ERCOT) . Potential solutions to addressing these challenges.

v) New approaches for grid stability assessment in grids with high to very-high IBR penetration. Such approaches will be critical for modeling future Indian power system with high levels of inverter-based distributed energy resources, power electronics loads, and battery storage

b) Hydro-Thermal-Renewable Scheduling and Coordination under High Variable Renewable Energy Integration

To improve hydro-thermal-renewable scheduling and coordination in system integration studies to fully exploit the benefits of hydro power in improving grid integration of renewable energy and minimizing greenhouse gas emissions, HRED, IIT Roorkee will

i) Perform stochastic modeling in hydro-thermal-renewable scheduling and coordination studies to improve the modeling of system operations under uncertainties associated with loads, renewable generation, and hydro power plants.
ii) Enable more accurate modeling of the water aspects in hydro power plants during hydro-thermal-renewable scheduling and coordination studies.
iii) Identify the benefits and challenges associated with "a" and "b".
iv) Present a roadmap for modeling and simulation of power systems under high variable renewable generation.

c) Advance Alert System for Silt Monitoring in Himalayan Rivers:

Both parties in association with Hydro Generating companies carry out a Pilot project on "Advance Alert System for Silt Monitoring System" involving the installation of an online instrument capable of monitoring sediments continuously upstream of a hydropower plant and plan the alert for operating hydro units.

d) Optimization Studies for Hydropower Stations in Cascade

i) To study and suggest Operation policy for hydro stations considering the existing and additional generation capacity planned from thermal, gas, hydro, PSP, wind and solar generation.
ii) Operational policy document study of hydro stations as per specifications which is including development of optimization model, development of hydrology model [inflow, outflow for environment flow & Irrigation], Study of barriers & transmission and regulatory constraints, and operational rules including data processing, documentation, communication.
iii) Suggest ways to achieve regulatory requirements with respect to operational parameters considering the present condition of the equipment.

e) To encourage research in the area of Wide area measurement systems (WAMS) and Cyber security:

f) POSOCO shall share the available data to HRED, IIT Roorkee to conduct above studies.

g) POSOCO will co-ordinate with hydro stations to provide the data/support required by HRED, IIT Roorkee to conduct the studies.

h) POSOCO shall share the benefits achieved from the services/study provided by HRED, IIT Roorkee at a regular interval and whenever specifically experienced.

i) POSOCO shall also endeavor to provide feedback on quantifiable savings, accrued due to usage of the information provided by HRED, IIT Roorkee EE, wherever applicable.

j) HRED, IIT Roorkee and POSOCO shall jointly publish papers for the purpose of knowledge sharing and information dissemination.

k) If any additional resources, are required during the pendency of this agreement for a specific assignment, a separate agreement shall be drafted and agreed upon clearly mentioning the additional scope of work.

2. OTHER FIELDS OF CO-OPERATION

Following are other areas of cooperation on which HRED, IIT Roorkee

a) Identification of issues of mutual interest and development of topics and possible means for exchanging information.

b) Providing expert opinion and knowledge support in areas of Weather information and its effect on power distribution system.

c) Consultancy in areas of mutual interest.

d) Capacity building of personnel in power sector through tailor made programs conducted by HRED, IIT Roorkee

e) Both the institutions shall evolve a mutually acceptable schedule to develop programs, hold seminars and exchange visits at International/National/regional/state level.

f) Sponsoring R&D projects, which may be carried out wholly at HRED, IIT Roorkee or at premises of POSOCO or partly at HRED, IIT Roorkee and partly at POSOCO

g) Working jointly for national and international R&D projects through various Government of India invitation.

h)Exchange of Data & Inputs to encourage further study and research work.

i) Any other appropriate area of collaboration agreed upon between the HRED, IIT Roorkee and POSOCO.

j) The parties may identify specific project(s) in any of the above areas and if required a separate agreement may be entered into between the two parties containing the details of

collaborative programs, roles and responsibilities of HRED, IIT Roorkee and POSOCO, and sharing of expenditure and facilities etc.

3. CONFIDENTIALITY

a) During and for a period of five years from the date of disclosure, each party agrees to consider as confidential all information identified as confidential by the disclosing party in written or tangible form or, if orally disclosed confirmed in writing within thirty days of disclosure.

b) The obligations above shall not extend to any confidential information for which the receiving party can prove that this information:

c) Is in the public domain at the time of disclosure or comes within the public domain without fault of the receiving party.

d) is already known or become known to the receiving party

e) is received from a third party having no obligations of confidentiality to the disclosing party,

f) is independently developed by the receiving party; or

g) is required to be disclosed by law or court order.

h) All the data not identified as confidential can be used for technical and research publication and can also be published in website for free access. For use of confidential data in publication written permission must be obtained.

4. NON-EXCLUSIVITY

l) The relationship of the parties under this MoU shall be non-exclusive and both parties, including their affiliates, subsidiaries and divisions, are free to pursue other agreements or collaborations of any kind. However, when entering into a particular research agreement, the participants may agree to limit each party's right to collaborate with others on that subject.

5. DURATION

a) This MoU, unless extended by mutual agreement of the parties, shall be valid for a period of five years from the date of execution of the MoU. This MoU may be amended and renewed by mutual agreement of the parties at any time.

6. TERMINATION

This MoU may be terminated by mutual agreement between the parties. However, either party shall have the right to unilaterally terminate this MoU giving 30 days prior written notice to the other party.

7. RELATIONSHIP

Nothing in this MoU shall be construed to make one party, a partner, an agent or legal representative of the other for any purpose. This MoU shall not create legal binding agreement between the parties.

8. COORDINATORS

There shall be nominated coordinator each, both from HRED, IIT Roorkee and POSOCO for implementation of this agreement.

9. INTELLECTUAL PROPERTY RIGHTS

The Intellectual Property Rights (IPR) that arise as a result of joint research and collaborative activity under the agreement will be worked out on a case to case basis and will be consistent with officially laid down IPR policies of the two parties.

10. ASSIGNMENT

It is understood by the Parties herein that this MoU is based on the professional competence and expertise of each party and hence neither Party shall transfer or assign this Agreement, or rights or obligations arising hereunder, either wholly or in part, to any third party.

11. COSTS

Each party shall bear its own cost for sharing of routine data. However, routine delivery of any service /products by IIT Roorkee to POSOCO may have exclusive requirements pertaining to hardware/software/telecommunication and manpower for the semi-operational mechanism. POSOCO shall bear the cost of these requirements. Quantum and other modalities in this regard shall be decided with mutual consent of both the parties on actual basis.

12. SETTLEMENT OFDISPUTE

Any dispute or differences arising out of or in connection with this MoU in the first place to the extent possible, be resolved amicably between the parties failing to which the same shall be resolved by arbitration. A sole arbitrator for this purpose shall be appointed jointly by both the parties. The place of arbitration shall be New Delhi and the arbitration proceedings shall be governed by the Arbitration and Conciliation Act 1996 as amended from time to time and the language of the arbitration shall be English.

The courts of New Delhi shall have the jurisdiction in case of any legal dispute.

13. COUNTERPARTS

This MoU may be executed in counterparts, each of which will be deemed an original.

IN WITNESS WHEREOF, the parties, here to acting through their duly authorized representative, have caused this Memorandum of Understanding to be executed, effective as of the day and year first above written.

(M K Singhal)
Head
Department of Hydro and Renewable Energy
IIT Roorkee

(Rajiv Porwal)
Chief General Manager (I/C)
Head NRLDC, POSOCO

Witness:

(Arun Kumar)
Professor,
Department of Hydro and Renewable Energy
IIT Roorkee

(Alok Kumar)
General Manager
NRLDC, POSOCO