Terms of Reference

INDEPENDENT AUDIT OF ELECTRICITY MARGINAL PRICE DISCOVERY IN PAKISTAN

1. Background and Context

Pakistan is implementing the Competitive Trading Bilateral Contract Market (CTBCM) to transition from a single-buyer model to a competitive wholesale electricity market. Under the CTBCM model:

- Market participants may enter into bilateral contracts to trade energy and/or capacity.
- Deviations from contracted and actual metered energy quantities (imbalances) will be settled through a centralized Balancing Mechanism for Energy (BME), administered by the Market Operator (MO), in accordance to the procedure and methodology in the Market Commercial Code.
- The System Operator (SO) conducts variable cost-based, Security Constrained Economic Dispatch (SCED) to schedule and instruct least-cost generation and administer ancillary services (and eventually load shedding in case of shortages or congestion) while ensuring system reliability, in accordance with the Grid Code.
- Both the MO and SO activities are separately licensed under a framework electricity law (the NEPRA Act) and consolidated under a single legal company: the Independent System and Market Operator (ISMO).
- Marginal prices are determined based on the results of the SCED and real time operation informed by the SO, through a methodology approved by the regulator in the Market Commercial Code.

Although CTBCM has only achieved commercial operation on January 22, 2026, prior to this date, the MO has been testing and publishing the indicative results of marginal prices based on the Market Commercial Code and the dispatch information and real time results provided by the SO. Given the critical role of marginal prices in the settlements of Market Participants under the BME, compensations for ancillary services, and investment and operational signals, ISMO seeks to engage an independent consulting firm to audit the accuracy and regulatory compliance of marginal price discovery in Pakistan.

2. Objectives of the Audit

The audit aims to:

- Confirm the accuracy and consistency of marginal price calculations published by ISMO.
- Evaluate whether SCED processes correctly integrate economic and system security constraints factors and are consistent with the Grid Code.
- Assess compliance with relevant regulations, rules, and operational standards set by the National Electric Power Regulatory Authority (NEPRA).

- Identify any errors or inefficiencies in marginal price discovery.
- Benchmark against international best practices for similar dispatch systems and provide recommendations.
- Recommend improvements to enhance the robustness and transparency of dispatch and marginal price discovery.

3. Scope of Work

To achieve the objectives of these Terms of Reference (TORs), the selected firm is expected to perform the following tasks in two parallel workstreams:

Workstream 1

3.1 Review of the Dispatch and Electricity Marginal Pricing frameworks

- Review and gain an understanding of the NEPRA approved codes related to the principles and methodologies for electricity marginal pricing and SCED (in particular the scheduling and dispatch code in the Grid Code and marginal prices methodology given in the Market Commercial Code).
- Gain an understanding of relevant provisions of Power Purchase Agreements (PPAs)[1], fuel supply contracts, and the SO dispatch procedures, for conducting SCED.

3.2 Evaluation of Security-Constrained Processes

- Based on the assessment in Task 3.1, carry out a high-level review of actual dispatches for FY 2024–25 (12 consecutive months of data) performed by the System Operator (SO), to develop a holistic understanding of dispatch outcomes. In addition, conduct a detailed review of actual dispatches for a sample of 48 days during FY 2024–25 to assess whether deviations from economic energy dispatch during this sample period were justified. The selection of the exact days of the year to be assessed within the sample period will be finalized by the firm in consultation with ISMO.
- Review day-ahead schedules for the sample period prepared by the SO using a unit commitment tool, that provides for the combined impact of constraints such as transmission limits, ramp rates, reserve requirements, minimum up/down times, and contingencies. The consultant will also advise on the adequacy of the tools and models used by the SO for day-ahead scheduling, including the forecasting tools and models.

[1] Power Purchase Agreements are largely standardized within each policy (1994, 2002, 2006, 2015 and 2019) and technology type (hydel, solar, wind, RFO, nuclear, coal, gas, and biofuel) making a full review of every agreement unnecessary for understanding scheduling, dispatch, and merit order formation. Only the relevant clauses on control, scheduling, operation, dispatch, variable cost submission, and tariff indexation need to be reviewed for sample PPAs under each technology/policy category for the intended analysis.

- Assess how constraints influence unit commitment, dispatch, and as a consequence electricity marginal prices.
- Undertake a comprehensive functional review of the existing SCADA-Energy Management System (EMS) environment from the perspective of supporting SCED and market operations. The review will assess how current SCADA telemetry, EMS network models, state estimation, contingency analysis, AGC readiness, and data quality, support or constrain, the effectiveness of existing SCED and Market Management System (MMS) applications used by the ISMO to identify gaps and give recommendations.
- Provide recommendations on optimizing dispatch based on international practices in markets similar to Pakistan (cost-based markets with centralized economic dispatch subject to system security constraints).

3.3 Assessment of Marginal Price Calculations

- Validate the calculation of Marginal Prices for the agreed upon sample period (48 days in FY 2024-25) to ensure mathematical accuracy.
- Determine whether published prices reflect the true short term marginal cost under the system constraints in Pakistan.
- Report on differences between prices calculated by the Consultant in compliance with the approved methodology and published prices (if any) and provide recommendations for improving data integrity, and consistency.

3.4 Compliance and Transparency Check

- Provide an assessment on compliance with Codes and other regulatory requirements, relevant to dispatch and marginal price calculations.
- Review the timeliness, detail, and accessibility of Marginal Price publications.

3.5 Benchmarking and Recommendations

- Compare Pakistan's practices for SCED and Marginal Price discovery with relevant international standards (in cost-based markets with centralized economic dispatch, where dispatch is based on variable costs). The Consultant, in its technical proposal, will propose the markets for ISMO consideration and approval that will be utilized for comparison.
- Provide recommendations to address gaps, improve efficiency and transparency, and mitigate any risks identified by the Consultant.
- Present key findings and recommendations to ISMO and other relevant stakeholders, as required.

Workstream 2

3.6 Audit of the Variable Cost of Generation

- All generators under CTBCM will be centrally dispatched by the SO based on their variable costs (sum of fuel costs and variable operations and maintenance costs). The SO publishes a fortnightly list on its website of the variable cost of all generators (in ascending order) connected to the national grid at 132 kV or higher voltages. The firm will be required to review two variable cost lists in detail (one each from winter and summer during FY2024-25) to confirm that the lists accurately reflect the relevant provisions of Power Purchase Agreements (PPAs) and fuel supply contracts etc., and input data like fuel costs, heat rates, variable operations and maintenance (O&M) expenses, and generator availability.
- Test for correct ranking of generation units based on least-cost principles in the two sample variable cost lists.

3.7 Recommendations

- Provide recommendations to address gaps, improve efficiency, and mitigate risks.
- Present key findings and recommendations to ISMO and other relevant stakeholders, as required.

4. Deliverables

4.1 Inception Report: Outline of methodology (updated from the methodology and plan provided in the technical proposal), work plan, data needs and system access requirements. (within 1 week of commencement).

Workstream 1

4.2 Interim Report: Preliminary findings and any urgent issues (midway through Workstream 1).

4.3 Draft Final Report: Comprehensive analysis, replicated calculations, and draft recommendations.

4.4 Final Report: Executive summary, detailed findings, conclusions, and prioritized recommendations with an implementation roadmap.

Workstream 2

4.5 Interim Report: Preliminary findings and any urgent issues. (mid-way through Workstream 2)

4.6 Draft Final Report: Comprehensive analysis and draft recommendations.

4.7 Final Report: Executive summary, detailed findings, conclusions, and prioritized recommendations with an implementation roadmap.

Consolidated Presentation on Workstreams 1 and 2

4.8 Presentations for ISMO (and other stakeholders if required) to discuss findings.

5. Qualifications of the Firm

- At least 10 years of relevant experience (the firm is required to provide documentary evidence of relevant experience).
- Successful completion of at least two similar assignments in the last 10 years (firms are required to provide details of completed assignments, including Client name and contract value).
- Demonstrated independence from Pakistani power sector market participants (firm expected to provide a declaration certifying no conflict of interest).

6. Duration and Timeline

The audit shall be completed within 6 months from contract award. Both Workstreams 1 and 2 will be implemented simultaneously (during Month 1 through Month 6), with the following major milestones:

Inception: Week 2

Workstream 1:

- Data analysis and fieldwork: Months 1-5
- Interim Report: Month 3
- Draft Report: Month 5
- Final Report: Month 6

Workstream 2:

- Data analysis and fieldwork: Months 1-5
- Interim Report: Month 3
- Draft Report: Month 5
- Final Report: Month 6

7. Estimated Level of Effort

The estimated level of effort (LOE) for the three experts over the duration of the assignment is as follows:

a. SCED Expert: 4.5 months
b. Market Expert: 3.5 months
c. Simulation Expert: 2.5 months

Consultants may propose their own LOE estimates, provided they are aligned with and justified in their proposed methodology. The Consultant may nominate additional non-key experts as part of the team. However, any non-key experts will not be considered or assigned a score in the Technical Evaluation.

8. Home and Field Office Requirements

The System Operations and SCED expert is expected to travel to Pakistan twice during the term of the assignment (in case experts are located abroad) and required to spend at least four weeks in the field office. Similarly, the Simulation and Dispatch Modelling expert, and the Market expert are expected to travel once to Pakistan and required to spend a minimum of two weeks each in the field office over the period of the assignment.

9. Data-sharing and Confidentiality

- The firm will be required to share data collection templates for all information required from the client. The templates will be approved by the client at the start of the assignment.
- ISMO will designate a counterpart (individual or team) at the organization for regular liaison with the Consultant and data sharing.
- ISMO will provide access to all confidential documents required for the assignment.
- Any information shared by ISMO with the firm will be governed by the confidentiality provisions set out in the respective instruments.

10. Reporting and Governance

- The firm will report to the Executive Directors System Operations at the ISMO with oversight by the ISMO Board of Director.
- All work must be evidence-based, independent, and confidential.

11. Expected Outcomes

The audit will validate the accuracy of marginal price discovery and SCED and highlight areas for improvement to support a more efficient and transparent electricity market in Pakistan.

12. Tasks, Qualification & Experience Requirement

Key Expert 1: System Operations and Security-Constrained Economic Dispatch (SCED) Expert / Team Lead

The SCED Expert is expected to:

- Perform the role of Team Lead.
- Carry out the activities defined in the Terms of Reference.
- Provide technical support to the other experts.
- Contribute to technical analysis and report writing.

Qualifications:
At least a Bachelor's degree in engineering. Master's degree or equivalent will be considered an added advantage.

Required Experience:

- Minimum 10 years of international experience in power system operations and centralized dispatch environments.
- Demonstrated hands-on experience with Security-Constrained Economic Dispatch or equivalent centralized dispatch frameworks.
- Strong knowledge of Grid Codes, system security criteria, reserve management, congestion management, and ancillary services.
- Prior experience in system operator reviews, independent audits, or regulatory assessments as a key expert is highly desirable.

Key Expert 2: Simulation and Dispatch Modelling Expert

The Simulation and Dispatch Modelling Expert is expected to:

- Carry out relevant activities defined in the Terms of Reference.
- Provide technical support to the other experts.
- Contribute to technical analysis and report writing.

Qualifications:
At least a Bachelor's degree in engineering, data sciences, economics or finance. Master's Degree or equivalent will be considered an added advantage.

Required Experience:

- Minimum of 10 years of international, hands-on experience in market simulation and dispatch modelling tools or software used globally in power markets, to simulate least cost dispatch and facilitate, day ahead or week ahead dispatch planning, hydrothermal coordination, security constraints optimization etc.
- Demonstrated experience in using these in competitive electricity markets with Security-Constrained Economic Dispatch or equivalent centralized dispatch frameworks.
- Strong knowledge of dispatch modelling tools, system security criteria, reserve management, congestion management, and ancillary services.
- Prior experience of similar reviews or independent audits is highly desirable.

Key Expert 3: Market Expert
The Market Expert is expected to: • Carry out relevant activities defined in the Terms of Reference. • Provide technical support to the other experts. • Contribute to technical analysis and report writing.
Qualifications: At least a bachelor's degree in engineering, science, finance, economics, or energy systems. Master's degree or equivalent will be considered an added advantage.
Required Experience: • Minimum 10 years of international experience in electricity market design, marginal pricing, balancing mechanisms, and market settlements in similar SCED based markets. • Demonstrated expertise in price formation methodologies in cost-based and centrally dispatched electricity markets. • Experience with regulatory frameworks, market codes, and pricing methodologies in competitive or transitional electricity markets. • Prior involvement in market design reviews, independent audits, or regulatory assessments is highly desirable.

13. Reporting Requirements and Time Schedule for Deliverables

This assignment shall be implemented under a **Lump-Sum Contract**. Payments under the contract shall be linked exclusively to the satisfactory completion and acceptance of deliverables and shall not be linked to the actual level of effort, time inputs, or personnel deployment by the Consultant. The Consultant shall be solely responsible for managing its personnel, resources, and time inputs to deliver the Services within the agreed lump-sum price.

14. Review and Acceptance of Deliverables

- The Client shall review submitted deliverables and provide consolidated comments within a reasonable review period.
- The Consultant shall address comments and resubmit revised deliverables where required.
- A deliverable shall be deemed accepted upon issuance of written acceptance by the Client.
- Acceptance of each deliverable shall constitute fulfillment of the corresponding contractual milestone, followed by the submission of an invoice by the Consultant to the Client corresponding to that deliverable.

15. Reporting and Coordination Arrangements

All reports, deliverables, and formal communications under this assignment will be submitted to the **Executive Director (System Operations) and Executive Director (Market Operations).**

16. Client's Input and Counterpart Arrangements

17.1 Client Inputs

The Client will provide the Consultant with reasonable access to information necessary for the conduct of the audit, including but not limited to:

- Applicable laws, regulations, Grid Code, Market Commercial Code, and NEPRA-approved procedures;
- Dispatch, SCED, operational, and marginal price data required for analysis, subject to confidentiality obligations;
- Access to relevant ISMO personnel for clarification and validation of factual information.
- Access to IT Systems and Applications of ISMO related to conduct a successful audit.

17.2 Counterpart Personnel assigned by the Client

Executive Director (System Operations) and Executive Director (Market Operations), will act as focal persons to coordinate with the Consultant, facilitate access to information, and consolidate feedback on submitted deliverables.

17. Duration of the Assignment

The total duration of the assignment shall be six (06) months from the date of commencement of Services.