Term of References (TORs)

Hiring of Consultancy Services for Industrial Emission Baseline, Fuel Mix Assessment and Regulatory Compliance Review

1. Background

Air pollution from industrial sources particularly **boilers, furnaces, large industrial stacks, brick kilns and stone crushing/construction sector** is a major environmental and public health concern in Punjab. Lahore Division and the surrounding industrial districts have repeatedly experienced hazardous air quality episodes, driven in part by inefficient combustion technologies, high-emitting fuels, and weak enforcement of environmental regulations. Recent episodes of extreme smog in Lahore, with AQI values reaching hazardous levels, have underscored the urgency of addressing industrial $PM_{2.5}$ and co-pollutant emissions at scale.

Under the **Punjab Clean Air Plan (PCAP)** and associated World Bank–supported interventions, the Government of Punjab aims to develop a **Punjab Clean Industry Transition Program** that is grounded in robust, spatially explicit evidence on emissions, technology use, and regulatory performance. Background analyses have partially identified **industrial pollution hotspots** and high $PM_{2.5}$ contributions from key sectors across **Lahore Division (Lahore, Kasur, Sheikhupura and Nankana Sahib districts)** and three additional industrial districts **Gujranwala, Sialkot and Faisalabad**. However, there is currently no integrated, geo-referenced baseline that brings together facility-level activity data, fuel mix, emissions, regulatory compliance status, and enforcement performance.

A credible **industrial emissions baseline and compliance assessment** is therefore a critical first step to:

- Understand the magnitude and distribution of $PM_{2.5}$ and associated pollutants (PM_{10}, SO_2, NO_x, BC, CO_2e) from priority industrial sources;
- Assess the effectiveness of existing regulatory and institutional arrangements (including PEQS/NEQS, Punjab Green Development Program, Boiler Inspectorate, EPA Punjab, and other relevant frameworks).
- To Asses all major and priority manufacturing units and industrial sources across the seven districts, particularly those with significant fuel consumption and emissions potential
- Identify short-term, high-impact mitigation opportunities; and
- Support the design of realistic, cost-effective **transition scenarios** to cleaner technologies and fuels.

This consultancy will provide the **technical foundation** for subsequent work streams on cleaner technologies, financing solutions and policy reforms by generating a robust, spatially explicit emissions baseline and inventory, mapping key stakeholders and regulatory actors, and developing initial cost-benefit based mitigation scenarios for priority sectors and districts.

2. Objectives

To develop a robust, geo-referenced **industrial emissions baseline and regulatory compliance assessment** for all industrial sectors in **Lahore Division and the districts of Gujranwala, Sialkot and Faisalabad**, and to generate initial, cost-benefit–based transition scenarios to inform the Punjab Clean Industry Transition Program. The specific objectives of the study are:

1. To establish a programmatic framework for industrial $PM_{2.5}$ reduction by mapping industrial sources and stakeholders and identifying process-level optimization and resource-efficiency opportunities across priority industrial clusters.

2. To develop a spatially explicit industrial emissions baseline and inventory for priority air pollutants, disaggregated by sector, fuel type, technology, and location, to support planning, compliance monitoring, and future MRV systems.
3. To assess industrial fuel mix, combustion and process technologies, and operational performance in order to identify the key technical and operational drivers of industrial emissions.
4. To review the industrial air-quality regulatory and compliance system, including institutional roles, enforcement capacity, and inter-agency coordination, to identify systemic gaps affecting effective implementation.
5. To identify, benchmark, and prioritize short-term mitigation measures and cost–benefit-based transition scenarios to inform implementation of the Punjab Clean Industry Transition Program under PCAP

3. Scope of Work:

1. Programmatic Framing for $PM_{2.5}$ Reduction through Process & Industrial Stakeholder Mapping

The consultant will:

1.1. Identify, map, and profile industrial stakeholders and all emitting units (including boilers, furnaces, brick kilns, power plants, stone crushing, large industrial stacks, high fuel-combustion units) across Lahore Division, Gujranwala, Sialkot, and Faisalabad, focusing on ownership, scale, and regulatory status.

1.2. Geo-tag and classify industrial clusters by production activity, sector type, technology category, and current compliance status, creating a spatial industry emissions map for program planning.

1.3. Identify and document process-level inefficiencies (poor combustion control, excessive energy use, low resource efficiency, unoptimized production cycles) using field observations.

1.4. Map regulatory entities and their mandates (EPA Punjab, Industries Department, Boiler Inspectorate, utilities, local governments, industrial estates), including inspection responsibilities, data flows, and enforcement jurisdiction in relation to industrial emissions.

1.5. Conduct initial consultations with industry associations and regulators to validate sectoral coverage and baseline assumptions, and to agree on data access protocols and strategies.

2. Development of Spatially Explicit Industrial Emissions Baseline & Emissions Inventory

The consultant will:

2.1. Collect facility-level activity data (equipment type, rated capacity, operating hours, fuels, production output, control devices) sufficient for emissions estimation, geo-coding etc.

2.2. Develop a geo-referenced baseline of emissions from all industrial point sources in the target districts, suitable for integration with AQM systems and regulatory planning.

2.3. Prepare a comprehensive emissions inventory for key pollutants: $PM_{2.5}$, PM_{10}, SO_2, NO_x, BC, and CO_2e, disaggregated by sector, fuel type, technology category, and location.

2.4. Apply validated emission factors (national, IPCC, GAINS/WHO or other accepted references) with documented assumptions ensuring that methods and documentation meet minimum requirements for use in MRV and carbon credit quantification under domestic and international standards.

2.5. Develop a digital database and analytics interface linking facility identifiers, activity data, emissions, and technology attributes, designed to be MRV-upgradable and interoperable with

future carbon registries and national carbon market data architectures (e.g. alignment of identifiers, data fields, and audit trails with national MRV and registry guidelines).

3. Diagnosis of Fuel Mix, Combustion Technologies & Alternative Fuel Options

The consultant will:

3.1. Characterize the current fuel mix (coal, biomass, natural gas, LPG, diesel, furnace oil, RDF, electricity) and combustion/process technologies used in boilers, furnaces, kilns, and large industrial stacks, including indicative technology configurations, operating conditions, and efficiency characteristics.

3.2. Assess combustion performance, process efficiency, and operational practices to identify key technical and operational drivers of industrial emissions, building on datasets developed under the emissions baseline.

3.3. Conduct an analytical assessment of technically feasible alternative fuels and pollution control options, focusing on technical applicability, operational implications, and indicative performance, without undertaking prioritization or investment design.

3.4. Review fuel supply chains and enabling conditions within Punjab, including availability, logistics, infrastructure readiness, pricing structures, and regulatory constraints, with a focus on implications for major industrial clusters.

4. Regulatory Compliance Review & Institutional/Enforcement Gap Assessment

The consultant will:

4.1. Review NEQS/PEQS standards, Boiler Inspectorate regulations, industrial zoning rules, and stack emission permitting thresholds.

4.2. Assess compliance of sampled facilities through document reviews, field visits, inspection record analysis, and interviews with regulatory staff.

4.3. Identify gaps in enforcement capacity, including technical equipment, staffing, inspection frequency, penalties, and monitoring systems.

4.4. Analyze institutional coordination challenges across EPA, Industries Department, Boiler Inspectorate, energy utilities, district authorities, and industrial estates.

4.5. Propose enhancements to monitoring, inspection, data management, and inter-agency coordination mechanisms.

5. Short-term mitigation and transition inputs

The consultant will:

5.1. Develop a menu of **short-term, operational and incremental hardware measures** suitable for Punjab's industrial sectors, framed as inputs for TOR-2's detailed technology/fuel packages.

5.2. Benchmark **industrial air-quality mitigation measures** and regulatory approaches from comparable countries and programs (India, Vietnam, China, Nepal, Egypt, RECP initiatives) to inform feasible "direction of travel".

5.3. Prepare **qualitative transition narratives** (BAU vs improved-compliance vs simple fuel/operational shifts) as inputs/assumptions for the subsequent studies.

5.4. Suggest preliminary priority actions for inclusion in the Punjab Clean Industry Transition Program (e.g. priority clusters, enforcement sequences, baseline data improvements), which the next subsequent studies then elaborate into technology/finance and carbon-market pathways.

4. Deliverables

The consultant is expected to provide the following deliverables:

SR#	Deliverable	Description	Duration
1	Inception report	Methodology, sampling and data collection design, QA/QC plan, institutional engagement plan, and detailed 8-month workplan and Gantt chart.	Month 1
2	MRV-ready data templates and database design note	Standardized data collection templates and database design (fields, identifiers, documentation standards) aligned with future MRV and carbon registry interoperability requirements.	Month 1
3	Industrial stakeholder and cluster mapping report	Geo-tagged industrial clusters, stakeholder and emitting unit profiles, and preliminary process inefficiency overview to support programmatic $PM_{2.5}$ reduction framing.	Months 1–2
4	Institutional and regulatory mapping note	Mapping of mandates, data flows, inspection responsibilities, and outline of the programmatic framework for industrial $PM_{2.5}$ reduction.	Months 1–2
5	Industrial emissions baseline and data system package	Facility-level dataset with metadata and QA/QC; spatial industrial emissions baseline with maps and summary statistics; multi-pollutant emissions inventory and methods note (MRV/carbon-ready); and operational digital database with user guide.	Months 2–5
6	Fuel mix and technology diagnostics report	Characterization of fuel mix by sector, combustion/process technology typology, performance gaps, and key technical and operational drivers of emissions.	Months 4–6
7	Fuel supply and enabling conditions brief	Assessment of fuel availability, logistics, infrastructure readiness, pricing patterns, and regulatory constraints affecting industrial fuel and technology choices.	Months 4–6
8	Regulatory compliance and institutional gap report	Review of NEQS/PEQS and related rules, sampled facility compliance assessment, enforcement capacity gaps, and institutional coordination challenges.	Months 4–6
9	Short-term mitigation options paper	Menu of quick-win operational and incremental hardware measures by sector/cluster, with qualitative indication of costs and implementation feasibility.	Months 6–8
10	International benchmarking note	Synthesis of relevant industrial air-quality mitigation and regulatory models from comparator countries and RECP programmes, adapted to Punjab's context.	Months 6–8
11	Programmatic framework and transition input report	Programmatic $PM_{2.5}$ reduction framework, qualitative transition narratives (BAU and improvement cases), priority clusters and enforcement/data sequences, and explicit inputs for subsequent TOR-2 and TOR-3 studies.	Months 6–8
12	Draft final report	Integrated report covering all objectives and scope items, with annexes on data, methods, and the interface with subsequent ToRs.	Month 8
13	Validation workshop materials and proceedings	Presentation deck, participant materials, and summary of stakeholder feedback and agreed revisions/actions.	Month 8
14	Final report and data/GIS package	Revised final report, finalized database and codebook, and all GIS layers/shapefiles delivered in agreed formats.	End of Month 8

6. Timeline

The consultancy is expected to be completed within 08 Months

7. Core Team Composition

The consultancy firm shall constitute a multidisciplinary team with demonstrated expertise in industrial emissions assessment, regulatory compliance, resource efficiency, and air quality management. The proposed team must collectively cover the technical, analytical, regulatory, and modelling competencies required under this assignment.

7.1. Team Leader / Senior Industrial Air Quality Specialist

A senior expert with a Master's or PhD in Environmental Engineering, Atmospheric Sciences, or a related discipline, with at least **15 years** of experience in industrial air quality management, emissions assessment, emission inventories and cleaner production initiatives. The Team Leader must have proven experience leading complex environmental/industrial assessments, Scientific Research, Algorithm development for emission factors, preferably for World Bank or comparable development-sector projects. Strong analytical, stakeholder engagement, and report synthesis competencies are essential.

7.2. Industrial Process & Resource Efficiency Specialist

Master's in Industrial Engineering, Mechanical Engineering, Chemical Engineering, or a relevant discipline. An industrial engineer or mechanical engineer with substantial experience (10 years) in industrial process optimization, energy efficiency, RECP (Resource Efficiency & Cleaner Production), and cradle-to-cradle approaches. The specialist should possess hands-on experience in conducting industrial audits, identifying process inefficiencies, and proposing low-cost operational improvements that directly reduce emissions.

7.3. Emissions Inventory & Air Pollution Modelling Expert

Master's or PhD in Environmental Engineering, Atmospheric Science, Environmental Sciences, Environmental engineering or Environmental management. An environmental scientist or engineer with at least 10 years of experience in developing facility-level or sectoral emissions inventories, applying international emission factor methodologies (IPCC, EEA, GAINS), and performing uncertainty analyses. Experience with air pollution modelling tools, emissions datasets, and industrial baseline development is required.

7.4. Industrial Energy System Specialist

Bachelor's Degree in Mechanical Engineering, Chemical Engineering, Energy Engineering, or related field. A mechanical or chemical engineer with specialized expertise in combustion systems, boiler and furnace efficiency, industrial heat processes, and fuel-switching options. The expert should have 5 years of relevant experience in assessing combustion technologies, comparative fuel performance, and evaluating alternative/cleaner fuels under local industrial conditions.

7.5. Industrial Regulatory & Compliance Specialist

Masters in in Environmental Policy, Environmental Law, Environmental Sciences, Public Administration. A professional with academic qualifications in Environmental Policy, Environmental Law, Environmental Sciences, or a related field, with a minimum of 5 years of experience in industrial environmental compliance, regulatory reviews, and enforcement system assessments. Required competencies include in-depth knowledge of NEQS/PEQS, Boiler Inspectorate regulations, PGDP frameworks, and institutional/governance assessments.

7.6. GIS & Spatial Analysis Expert

Bachelor's or Master's in GIS, Geography, Remote Sensing or Environmental Sciences. A specialist with a background in GIS, geography, or remote sensing, and at least 5 years of relevant experience in spatial data processing, facility mapping, emissions hotspot analysis, and preparation of geo-referenced industrial datasets. Familiarity with GIS tools such as ArcGIS/QGIS is required.

7.7. Industrial Data Systems / MRV & Database Specialist

Master's degree in environmental engineering, Environmental Sciences, Data Science, Information Systems, or a related field. A data and systems specialist with at least 5 years of professional experience in design, management, and analysis of environmental or industrial datasets, including emissions inventories, compliance databases, or monitoring systems, verification and reporting.

7.8. Environmental Economist / Data Analyst

Master's in Economics, Environmental Economics, Public Policy, or related fields. An economist or policy analyst with at least 5 years of experience in cost–benefit analysis, economic modelling of environmental interventions, health impact assessment, and analysis of air pollution–related socioeconomic impacts. Expertise in quantifying benefits of mitigation scenarios is essential.

7.9. Field Survey Engineers / Data Collection Specialists (Positions: 05)

Professionals with degrees in Environmental Engineering, Mechanical Engineering, Industrial Engineering, or related fields, and 3 years of experience in industrial surveys, facility profiling, and technical data collection. They should be capable of conducting structured field assessments and working with industries to obtain accurate operational and fuel-use information.

7.10 Research & Documentation Associate (Positions: 03)

Bachelor's or Master's degree in Environmental Sciences, Engineering, Public Policy, or related discipline. A junior-level team member with 3 years of experience in environmental research, data organization, technical documentation, and supporting the preparation of analytical reports. Competency in data management and literature review is essential.

8. Reporting and Governance

The consultant will report to **PD, PCAP-CMU** and work in close coordination with designated focal points. Regular progress updates and stakeholder engagement meetings will be required.

9. Payment Schedule

Payments will be made based on the successful completion of deliverables, as follows:

SR#	Milestone	Linked deliverables (from table)	Timing	Payment share (%)
1	Contract signature and approved Inception Package	1–2: Inception report; MRV-ready data templates & database design	End of Month 1	10
2	Completion of mapping and institutional framing phase	3–4: Stakeholder & cluster mapping; institutional/regulatory note	End of Month 2	10
3	Delivery and acceptance of Industrial Emissions Baseline & Data System Package	5: Industrial emissions baseline and data system package	End of Month 5	35
4	Delivery of fuel/technology diagnostics and regulatory/institutional gap assessment reports	6–8: Fuel mix & technology report; fuel supply brief; compliance/gap report	End of Month 6	15

5	Delivery of mitigation, benchmarking and programmatic framework/transition inputs	9–11: Mitigation options paper; benchmarking note; framework & inputs report	End of Month 8	20
6	Submission and approval of Final Package	12–14: Draft & final reports; validation workshop outputs; final data/GIS package	End of Month 8	10

The Consultancy firm will be selected in accordance with the Consultant's Qualification Based Selection (CQS) as defined in the World Bank Procurement Regulations.