**Term of References (TORs)**

**Hiring of Consultancy services for Cleaner Technologies, Fuel Transition Pathways and Financing Mechanisms**

## 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.

This consultancy is designed to be informed by, and aligned with, ongoing and recent industrial air quality diagnostics in Punjab, including assessments of industrial emissions, fuel and technology characteristics, and identification of priority industrial sectors and clusters. Within this broader analytical context, the assignment focuses on evaluating cleaner technologies, alternative fuels, feasibility conditions, and transition pathways suited to Punjab's industrial landscape.

Punjab's industrial landscape is characterized by a combination of outdated combustion technologies, poor thermal efficiency, limited fuel-switching options, and inadequate adoption of modern cleaner production practices. Although policy frameworks exist, industries face major barriers in transitioning to cleaner technologies, including high upfront investment costs, lack of access to finance, insufficient technical knowledge, and gaps in regulatory enforcement.

The Government of Punjab, under the Punjab Clean Air Plan (PCAP), aims to develop a **Punjab Clean Industry Transition Program**. This requires a rigorous understanding of:

- the technological readiness of cleaner options,
- their operational and economic feasibility,
- policy and regulatory enablers needed for adoption,
- financing barriers faced by industrial units, and
- potential for a dedicated **clean technology credit facility** to support adoption.

To reduce industrial air emissions and support the province's environmental and climate commitments, it is essential to undertake a systematic and technical assessment of cleaner combustion technologies, alternative and less-polluting fuels, and cost-effective transition pathways that are compatible with local operational, financial and regulatory realities. This includes evaluating the feasibility of various technological upgrades, fuel-switching options, energy-efficient systems, and potential mechanisms to support cleaner technology adoption including the establishment of a clean technology or cleaner production credit facility.

This consultancy will provide the Government of Punjab with a detailed, evidence-based assessment of technological alternatives, cleaner fuels, financial and regulatory enablers, and actionable transition scenarios to inform the design of a practical and scalable industrial clean-technology transformation program for the province.

## 2. Objectives

To evaluate cleaner technologies, less-polluting combustion fuels, and feasible transition pathways for major industrial sectors in Punjab, and to recommend technically sound, economically viable, and policy-ready solutions for reducing $PM_{2.5}$ and co-pollutant emissions.

1. To analyze the existing fuel mix, efficient combustion technologies used in boilers, furnaces, brick kilns, power plants and all industrial stacks in Lahore Division and the selected districts, including their emission and efficiency profiles based on the data set collected from preceding study.
2. To identify, screen, and technically assess transition-ready cleaner combustion technologies and alternative, less-polluting fuels in order to support investment decisions and large-scale adoption under Punjab's industrial transition program
3. To assess the technical, financial, and regulatory feasibility of adopting cleaner technologies and alternative fuels in priority industrial sectors, including key barriers and enablers.
4. To assess the feasibility of establishing a cleaner production or cleaner technology credit facility to vet, approve, and issue soft loans and other financial instruments for pollution abatement technologies in Punjab's industrial sector.
5. To develop decision-grade, cost–benefit-based technology and fuel-switch transition scenarios, quantify associated emission and health benefits, and formulate policy recommendations and an implementation roadmap to enable large-scale adoption of cleaner technologies and fuels under the Punjab Clean Industry Transition Program.

**3. Scope of Work:**

**1. Assessment of Current Fuel Mix and Combustion Technologies**

The consultant will:

1.1. Use TOR-1 fuel and technology diagnostics as the starting point; deepen analysis where needed (e.g. detailed combustion parameters, system-level efficiencies) for sectors selected as "transition priority sectors".

1.2. Characterize thermal systems and burner configurations in more detail (e.g. control systems, turndown ratios, heat recovery), focusing on parameters relevant to technology upgrade and fuel-switch decisions.

1.3. Identify operational inefficiencies, poor combustion control, suboptimal thermal performance, and fuel-use trends contributing to elevated particulate and gaseous emissions.

1.4. Evaluate combustion practices, load factors, air–fuel ratios, and maintenance routines that influence emissions and energy efficiency.

1.5. Categorize industries based on fuel type, combustion technology, and overall energy/emissions profile to inform transition planning.

1.6. Characterize the applicability and current uptake of Cleaner Production (CP), Resource Efficiency & Cleaner Production (RECP), and cradle-to-grave approaches within existing industrial operations

**2. Identification and Evaluation of Cleaner Technologies and Alternative, Less-Polluting Fuels**

The consultant will:

2.1 Identify cleaner combustion technologies relevant to Punjab's industrial sectors, including high-efficiency boilers/furnaces, modern brick kiln designs, improved burners, heat recovery systems, waste-heat utilization, and hybrid or electric thermal systems.

2.2 Evaluate feasible alternative fuels, including biomass pellets, briquettes, RDF, LPG conversions, electrification options, and hydrogen blending, assessing compatibility with current industrial processes.

2.3 Assess the technical, economic, and operational viability of cleaner technologies and alternative fuels for each priority sector.

2.4 Examine control devices and abatement technologies, including filter systems, scrubbers, ESPs, cyclones, and advanced particulate control mechanisms, identifying efficiencies, lifetimes, operating costs, and required maintenance.

2.5 Identify key sectoral adoption barriers, including technical constraints, infrastructure limitations, supply chain gaps, skilled workforce availability, and equipment compatibility.

**3. Technical, Financial and Regulatory Feasibility Assessment**

The consultant will:

3.1 Conduct cost assessments for the adoption of alternative fuels and cleaner technologies, including CAPEX, OPEX, payback periods, fuel cost impacts, installation requirements, and retrofit needs.

3.2 Assess the regulatory and policy feasibility of adopting shortlisted cleaner combustion technologies, focusing on transition enablers, constraints, and required adjustments within existing NEQS/PEQS, energy policies, zoning rules, and permitting frameworks.

3.3 Identify regulatory gaps or misalignments that may hinder adoption of cleaner technologies and fuels, with reference to transition requirements rather than compliance status.

3.4 Analyze economic and operational risks faced by industries in shifting to cleaner options and propose feasible mitigation strategies.

3.5 Assess sector-level readiness based on technological maturity, market availability, financial viability, and energy infrastructure constraints.

**4. Feasibility Assessment for a Cleaner Production / Clean Technology Credit Facility**

The consultant will:

4.1 Assess the feasibility of establishing a clean technology financing mechanism, including a dedicated credit facility, soft-loan program, on-lending structure, or blended finance model.

4.2 Identify financial intermediaries, banks, and institutions capable of managing clean technology lending programs in Punjab.

4.3 Define eligibility criteria for technologies suitable for financing, including minimum production capacities, efficiency thresholds, and emissions reduction potential.

4.4 Propose financial terms and conditions, including interest concessions, repayment periods, grace periods, co-financing requirements, and risk mitigation instruments.

4.5 Identify technical assistance partners for due diligence, technology verification, cost validation, and monitoring of financed mitigation solutions.

4.6 Map potential linkages with national and international carbon finance mechanisms, green credit programs, or climate funds.

**5. Scenario Development, Impact Modelling and Policy/Implementation Roadmap**

The consultant will:

5.1 Develop multiple transition scenarios, including Business-as-Usual (BAU), fuel-switch pathways, cleaner technology upgrade scenarios, and regulatory-compliance improvement scenarios.

5.2 Conduct cost–benefit analyses for each scenario, quantifying economic costs, emissions reductions, operational savings, and technology switching impacts.

5.3 Estimate health and environmental benefits using concentration–response functions, population exposure models, and spatial impact analysis.

5.4 Develop an industrial transition roadmap, with short-, medium- and long-term milestones for adopting cleaner technologies and alternative fuels.

5.5 Recommend reforms in policy, regulation, incentives, and industrial support programs required to scale technological and fuel transitions.

5.6 Propose mechanisms for institutional coordination, monitoring, and industry engagement to support sustained adoption.

**4. Deliverables**

The consultant is expected to provide the following deliverables:

| # | Deliverable | Description | Timeline |
|---|---|---|---|
| 1 | **Inception Report & Detailed Methodology** | Detailed methodology, analytical framework, sector prioritization, data collection tools, fuel/technology assessment approach, and stakeholder engagement plan. | Week 2 |
| 2 | **Current Fuel Mix & Combustion Technology Assessment Report** | Assessment of fuel types and combustion technologies across boilers, furnaces, kilns, and stacks, emphasizing performance, efficiency, fuel-use trends, and implications for cleaner technology transition | Week 6 |
| 3 | **Cleaner Technologies & Alternative Fuels Screening Assessment** | Technical and economic evaluation of cleaner combustion technologies, alternative fuels (biomass, briquettes, LPG, NG, RDF, electrification, hydrogen blends), abatement technologies, control devices, sectoral adoption barriers. A screening-level assessment of cleaner combustion technologies and alternative fuels applicable to priority industrial sectors, focusing on technical suitability, operational compatibility, maturity, and **indicative cost ranges**, without undertaking detailed investment or financial feasibility analysis. | Week 10 |
| 4 | **Technical, Financial & Regulatory Feasibility Study** | A decision-grade feasibility assessment of shortlisted cleaner technologies and fuel-switch options, including detailed CAPEX/OPEX analysis, payback periods, regulatory and permitting feasibility, infrastructure requirements, financing considerations, and implementation risks, to support investment and policy decision-making | Week 14 |
| 5 | **Feasibility Assessment of Clean Technology / Cleaner Production Credit Facility** | Evaluation of potential financing mechanisms; criteria for eligible technologies; proposed terms; financial intermediaries; risk mitigation tools; TA needs; linkages to carbon finance. | Week 16 |
| 6 | **Transition Scenario Modelling & Cost –Benefit Analysis Report** | BAU and mitigation scenarios; technology-switch pathways; fuel-switch scenarios; economic, health, and emissions reduction modelling; quantified co-benefits. | Week 20 |
| 7 | **Policy Recommendations & Implementation Roadmap** | Policy, regulatory and incentive reforms; phased roadmap (short-, medium-, long-term); institutional arrangements; enabling environment for adoption of cleaner fuels and technologies. | Week 22 |

| # | Deliverable | Description | Timeline |
|---|---|---|---|
| 8 | **Final Consolidated Report** | Comprehensive report integrating all deliverables, datasets, scenario models, policy recommendations, and implementation pathways. | Week 24 |

## 6. Timeline

The consultancy is expected to be completed within 6 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 Cleaner Technologies & Industrial Transition Specialist

**Qualifications:**

- Master's or PhD in Mechanical Engineering, Industrial Engineering, Environmental Engineering, Energy Systems, or a related field.

**Experience:**

- Minimum 15 years of professional experience in industrial cleaner technologies, fuel-switching, process efficiency, or thermal system upgrades.
- Proven experience leading multi-sector industrial assignments for development partners (World Bank, ADB, GIZ, UNIDO, etc.).

**Relevant Expertise:**

- Deep knowledge of combustion technologies, energy efficiency, RECP, alternative fuel systems, and industrial decarbonization.
- Strong leadership, analytical skills, and ability to coordinate with industry, government, and technical institutions.

### 7.2. Industrial Combustion Technology & Fuel Systems Expert

**Qualifications:**

- Master's or Bachelor's degree in Mechanical, Chemical, or Energy Engineering.

**Experience:**

- Minimum 10 years of experience in combustion systems, industrial thermal processes, boilers, furnaces, kilns, stack operations, and heat recovery.

**Relevant Expertise:**

- Hands-on expertise in evaluating thermal efficiency, air–fuel ratio optimization, combustion diagnostics, and fuel system retrofits.
- Knowledge of advanced burners, hybrid thermal systems, electrification, and modern kiln/furnace technologies.

### 7.3. Cleaner Technologies & Abatement Systems Specialist

**Qualifications:**

- Degree in Mechanical Engineering, Environmental Engineering, or Industrial Engineering.

**Experience:**

- Minimum 7 years in cleaner production, abatement technologies, particulate control devices, and pollution mitigation technologies.

**Relevant Expertise:**

- Familiarity with ESPs, bag filters, scrubbers, cyclones, low-NOx burners, waste-heat recovery systems, and emerging clean-tech solutions.
- Ability to assess technology performance, O&M practices, lifespan, retrofitting needs, and cost implications.

### 7.4. Alternative Fuels & Energy Transition Specialist

**Qualifications:**

- Degree in Energy Engineering, Mechanical Engineering, Chemical Engineering, or Renewable Energy.

**Experience:**

- At least 7 years of experience with biomass fuels, briquettes, pellets, RDF, LPG, natural gas, electrification, hydrogen co-firing, and hybrid systems.

**Relevant Expertise:**

- Strong knowledge of fuel-switching pathways, fuel supply chains, infrastructure requirements, and sector-level adoption constraints.
- Experience assessing operational feasibility, supply availability, storage, and safety considerations.

### 7.5. Environmental Economist / Techno-Economic Analyst

**Qualifications:**

- Master's in Environmental Sciences, Economics, Energy Economics, Public Policy, or a related field.

**Experience:**

- Minimum 5 years in cost–benefit analysis, economic modelling, energy system economics, or industrial technology evaluation.

**Relevant Expertise:**

- Ability to quantify cost savings, payback periods, CAPEX/OPEX impacts, and economic viability of technology and fuel-switch scenarios.
- Experience modelling health/environmental co-benefits.

### 7.6. Climate Finance & Clean Technology Credit Facility Specialist

**Qualifications:**

- Master's degree in Finance, Sustainable Finance, Economics, Development Finance, Business Administration, or a relevant field.

**Experience:**

- Minimum 7 years of experience in climate finance, green lending products, credit facility design, or financial structuring.

**Relevant Expertise:**

- Knowledge of green credit lines, concessional loans, risk mitigation instruments, carbon finance, and investment feasibility studies.
- Experience engaging with banks, DFIs, and financial intermediaries.

### 7.7. Industrial Policy & Regulatory Analyst

**Qualifications:**

- Master's degree in Public Policy, Environmental Policy, Environmental Law, Development Studies, or related fields.

**Experience:**

- Minimum 5 years of experience in industrial policy analysis, regulatory frameworks, sustainability standards, or environmental governance.

**Relevant Expertise:**

- Strong understanding of NEQS/PEQS, industrial zoning rules, energy sector regulations, and policy incentives for cleaner technology adoption.
- Ability to propose regulatory reforms and institutional strengthening measures.

### 7.8. Scenario Modelling & Air Quality Impact Specialist

**Qualifications:**

- Degree in Environmental Sciences, Atmospheric Sciences, Environmental Engineering, or related discipline.

**Experience:**

- Minimum 5 years in scenario modelling, air quality impact assessment, concentration–response modelling, or industrial emissions analysis.

**Relevant Expertise:**

- Ability to model emission reduction pathways, health benefits, and environmental impacts under technology and fuel-switch scenarios.

### 7.9 Industrial Finance & Banking Operations Specialist

**Qualifications:**

- Master's degree in Finance, Banking, Economics, Development Finance, Business Administration, or a related field. Professional certifications in finance, risk management, or sustainable finance will be an advantage.

**Experience:**

- Minimum 10 years of professional experience in industrial finance, banking operations, credit appraisal, or lending for manufacturing, energy, or infrastructure projects.
- Proven experience working with commercial banks, DFIs, or development partners on industrial lending products, credit lines, or on-lending facilities, preferably linked to energy efficiency, cleaner production, or environmental investments.
- Demonstrated involvement in the design or operation of credit facilities, concessional finance instruments, or blended-finance mechanisms.

**Relevant Expertise:**

- Strong understanding of industrial credit appraisal, loan structuring, risk assessment, collateral requirements, and borrower due diligence for manufacturing enterprises.
- Experience assessing CAPEX/OPEX, cash flows, payback periods, and financial viability of industrial technology investments.
- Familiarity with banking regulations, prudential requirements, and operational processes relevant to deploying clean-technology or cleaner-production credit lines.
- Ability to support the design of clean technology or cleaner production credit facilities, including eligibility criteria, lending procedures, risk-sharing mechanisms, and coordination with technical verification teams.

**7.9. GIS & Spatial Data Analyst**

**Qualifications:**

- Bachelor's/Master's in GIS, Geography, Remote Sensing, Environmental Science, or Data Science.

**Experience:**

- At least 3 years managing spatial datasets, industrial mapping, hotspot identification, and GIS-based visualization.

**Relevant Expertise:**

- Proficiency in ArcGIS/QGIS; ability to integrate spatial layers with technology/fuel datasets.

**7.10. Field Data Collection & Technical Survey Team (4 Positions)**

**Qualifications:**

- Bachelor's degree in Mechanical, Industrial, Electrical, or Environmental Engineering.

**Experience:**

- 3 years of experience conducting industrial surveys, facility audits, equipment profiling, or field diagnostics.

**Relevant Expertise:**

- Skilled in using field tools, structured questionnaires, and coordinating with industrial facilities.

## 8. Payment Schedule

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

| SR# | Milestone | Linked Deliverable(s) | Timing | Payment share (%) |
|---|---|---|---|---|
| 1 | Approval of Inception Report & Detailed Methodology | 1. Inception Report & Detailed Methodology | Week 2 | 10 |
| 2 | Submission and acceptance of Fuel Mix & Combustion Technology Assessment | 2. Current Fuel Mix & Combustion Technology Assessment Report | Week 6 | 10 |
| 3 | Submission and acceptance of Screening Assessment of Cleaner Options | 3. Cleaner Technologies & Alternative Fuels Screening Assessment | Week 10 | 15 |

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|---|---|---|---|---|
| 4 | Submission and acceptance of Technical, Financial & Regulatory Feasibility Study | 4. Technical, Financial & Regulatory Feasibility Study | Week 14 | 20 |
| 5 | Submission and acceptance of Credit Facility Feasibility Assessment | 5. Feasibility Assessment of Clean Technology / Cleaner Production Credit Facility | Week 16 | 10 |
| 6 | Submission and acceptance of Transition Scenario & CBA Report | 6. Transition Scenario Modelling & Cost–Benefit Analysis Report | Week 20 | 15 |
| 7 | Submission and acceptance of Policy Recommendations & Roadmap | 7. Policy Recommendations & Implementation Roadmap | Week 22 | 10 |
| 8 | Approval of Final Consolidated Report | 8. Final Consolidated Report (integrating all preceding deliverables) | Week 24 | 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.