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PROBLEM STAMENT

The increasing accumulation of plastic waste, end-of-life tyres, and used lubrication oil presents a significant environmental liability and a growing operational challenge for the waste-to-energy sector. While pyrolysis technology is currently deployed for converting these waste streams into fuel, existing commercial systems continue to face technical and economic limitations. These include non-optimized feedstock blending, inconsistent liquid fuel yield, high specific electrical energy consumption, elevated sulphur content in derived fuel fractions, and inadequate emission control performance. These constraints reduce overall process efficiency, increase operating cost, and limit scalability and regulatory acceptance.

In heterogeneous waste processing, improper feed ratio management leads to unstable reaction behavior, reduced condensable hydrocarbon yield, higher coke formation, and increased non-condensable gas generation. Additionally, current reactor configurations often exhibit higher electrical energy demand, directly affecting fuel production cost and industrial competitiveness. Sulphur-rich fractions, particularly from tyre-derived components, further reduce fuel quality and require improved upgrading strategies. Emission control remains a concern in ensuring compliance with environmental standards and enhancing community acceptance of pyrolysis facilities.

The company therefore seeks to address these operational gaps through a comprehensive process optimization initiative. The targeted outcomes include achieving ≥70 wt.% liquid fuel yield through systematic feed composition optimization and improved reactor design. The system must demonstrate a measurable 15–20% reduction in specific energy consumption compared to existing baseline pyrolysis systems. The derived fuel must achieve sulphur content below 20 ppm through an integrated upgrading strategy. Additionally, the optimized system should demonstrate at least a 20% reduction in gaseous emissions (CO, SOx, and smoke intensity) under controlled validation trials.

The proposed solution should include fabrication and pilot-scale validation of an energy-efficient reactor configuration suitable for industrial deployment. A detailed techno-economic evaluation is required to establish projected fuel production cost below ₹55–60 per litre under scaled operation. Further, carbon mitigation assessment must quantify CO_2-equivalent reduction per tonne of waste processed to support sustainability benchmarking and carbon credit potential.

The company expects the proposed framework to integrate feed optimization, energy reduction, sulphur control, emission mitigation, and commercial validation into a unified industrial solution. The objective is to advance the technology from laboratory proof-of-concept (TRL 3) to pilot-scale validation (TRL 6), thereby enabling commercialization readiness. The intended outcome is the development of an energy-efficient, low-emission, and economically viable waste-to-fuel conversion platform aligned with circular economy principles and industrial decarbonization goals.

Success / Completion Criteria

1. Technical Innovation & Process Optimization

The company seeks development of an optimized reactor configuration capable of achieving ≥70 wt.% liquid fuel yield under controlled operating conditions. Current operational systems show variability in yield due to inconsistent feed blending and sub-optimal process control. The proposed solution should establish systematic feed composition optimization strategies to enhance reaction synergy and minimize coke formation. Key operational parameters including temperature profile, heating rate, and residence time must be optimized to ensure stable and consistent product distribution. Achieving sustained liquid yield beyond 70 wt.% will validate improved process efficiency compared to existing baseline systems.

2. Energy Efficiency & Operational Improvement

The company requires a measurable reduction in specific electrical energy consumption by 15–20% relative to current pyrolysis operations. Electrical input per kilogram of feed must be quantified and benchmarked against existing industrial data. The proposed solution should incorporate reactor design improvements such as enhanced thermal uniformity, improved insulation, and optimized heating control to reduce energy intensity. Demonstrating this reduction will directly improve operational cost structure and enhance industrial competitiveness.

3. Environmental Compliance & Emission Reduction

The company expects the developed system to demonstrate at least 20% reduction in gaseous emissions, including CO, SOx, and smoke intensity, during controlled validation trials. Additionally, the derived fuel must achieve sulphur concentration below 20 ppm to align with low-sulphur fuel standards. Emission measurements should be conducted using standardized protocols to ensure regulatory compliance. Meeting these targets will strengthen environmental acceptance and operational sustainability.

4. Product Quality & Upgrading Performance

The company requires the derived fuel to meet improved quality parameters suitable for diesel engine application. Upgrading strategies must ensure sulphur reduction below 20 ppm while maintaining desirable fuel characteristics. Key parameters including calorific value, viscosity, flash point, and density should meet acceptable industrial standards. Demonstration of consistent fuel quality will confirm market readiness and usability.

5. Techno-Economic Viability

A comprehensive techno-economic assessment must be conducted to evaluate capital investment, operating expenditure, feedstock cost, energy consumption, and upgrading expenses. The company targets a projected fuel production cost below ₹55–60 per litre under scaled operational conditions. Sensitivity analysis should be performed to assess economic stability under variable electricity tariffs and feedstock pricing scenarios. Achieving this benchmark is essential for commercial deployment.

6. Carbon Mitigation & Sustainability Impact

The company requires quantification of carbon mitigation potential through CO_2-equivalent reduction assessment per tonne of waste processed. The analysis should consider avoided landfill emissions, fossil fuel displacement, and emission reduction during processing. This evaluation will support carbon credit estimation and enhance the environmental positioning of the technology. Demonstrating measurable carbon reduction will strengthen alignment with state and national sustainability goals.

7. Prototype Development & Industry Validation (TRL Advancement)

The company expects fabrication and pilot-scale validation of an energy-efficient reactor configuration suitable for industrial deployment. The system must demonstrate stable performance under industrially relevant operating conditions. Validation in collaboration with the company should confirm technical feasibility, emission compliance, and economic viability. The intended objective is advancement of technology maturity from TRL 3 (experimental proof-of-concept) to TRL 6 (pilot-scale demonstration in relevant environment), enabling readiness for commercialization and scale-up.