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Used Oil Re-Refining Infrastructure Gap in Kazakhstan
Economic Analysis, Technology Assessment & Strategic Infrastructure Recommendations

With Specific Reference to Inclined Wall Wiped Film Vacuum Distillation Technology

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An Evidence-Based Technical, Scientific & Environmental Assessment

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Target Audience: Government & Regulatory Bodies · Private Sector Investors & Industrial Operators
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Abstract

*Kazakhstan generates an estimated 120,000–180,000 tonnes of used lubricating oil (*includes process oils, hydraulic fluids, and transformer oils across the entire industrial base, not just lubricating oil returned as collectible used oil.*) annually from its oil extraction, refining, mining, manufacturing, and transport sectors — yet possesses no dedicated Group I or Group II re-refining facility. Formal used oil collection rates stand at approximately 20–30%, while the remainder is informally combusted, illegally dumped, or lost — a resource and environmental catastrophe worth hundreds of millions of dollars in foregone value. This Technical Report quantifies the infrastructure gap, benchmarks it against global and regional comparators, and assesses the technical and economic viability of closing it through the deployment of inclined wall wiped film vacuum distillation technology. Drawing on peer-reviewed literature, industrial feasibility data from a reference 30,000 tonne per annum facility design developed for Almaty, and Kazakhstan's Environmental Code 2021 framework, we demonstrate that vacuum distillation offers a chemically clean, waste-free re-refining pathway yielding 84–90% base oil recovery without acid, clay, or hydrogen input. The Steerkraft reference design projects a 96% internal rate of return, a 2.2-year payback period, and annual after-tax profits of approximately CNY 43.6 million (USD 6 million) per 30,000 tonne unit — vendor projections that this report treats as the central hypothesis to be independently validated, not as established findings. Scaled to Kazakhstan's available feedstock, the re-refining opportunity represents a USD 115–210 million annual economic prize that is currently being destroyed through combustion and illegal disposal. The paper concludes with infrastructure deployment recommendations calibrated to Kazakhstan's regulatory framework, refinery geography, and Green Economy 2050 commitments.*

Keywords: *Kazakhstan, used lubricating oil, re-refining, vacuum distillation, wiped film evaporation, infrastructure gap, circular economy, Environmental Code 2021, KazMunayGas, EEESEF*

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1. Introduction: The Scale of the Problem

1.1 Kazakhstan's Oil Economy and Lubricant Consumption

Kazakhstan is one of the world's most significant hydrocarbon economies, holding approximately 30 billion barrels of proven oil reserves — the 12th largest reserve base globally — and producing 87.7 million tonnes of crude oil in 2024.[18] The country's three principal refineries, at Atyrau (5.47 Mt/yr), Pavlodar (5.76 Mt/yr), and Shymkent (6.23 Mt/yr), processed a combined 17.6 million tonnes of crude in 2024, underpinning a vast industrial lubricant demand that spans oil extraction, pipeline transport, mining, manufacturing, agriculture, and road transport.[27][28]

Central Asia as a whole consumed approximately 300,000 tonnes of finished lubricants in 2021, with Kazakhstan accounting for the largest national share — estimated at approximately 200,000 tonnes per year.[19] Lukoil operates a blending facility in Almaty with a capacity of 100,000 tonnes per year, importing base oils from Perm and Volgograd. Hill Corp operates a blending plant in Shymkent at 70,000 tonnes per year. Neither entity conducts re-refining: both are downstream blenders importing virgin or re-refined base oil from abroad.[19][20]

The Tengiz, Kashagan, and Karachaganak mega-fields generate enormous streams of drilling and process lubricants, while Kazakhstan's transport fleet — supporting 63.0 million tonnes of oil exports through the Caspian Pipeline Consortium in 2024 — creates continuous high-volume lubricant consumption across all machinery classes.[18] This lubricant economy is the feedstock for Kazakhstan's un-captured re-refining opportunity.[35]

1.2 The Used Oil Generation Estimate

Based on the industrialised-economy ratio of approximately 40–48% of lubricants consumed returning as collectible used oil, Kazakhstan's estimated 200,000+ tonne lubricant market generates roughly 60,000–80,000 tonnes of used lubricating oil annually from automotive and commercial sources alone.[5][17] Industrial and mining operations — including the Tengiz, Kashagan, and Karachaganak field operations, the Karaganda coal mining complex, and the Balkhash copper smelter — contribute an additional estimated 60,000–90,000 tonnes or more of process and machinery oils annually.[12]

The total used oil stream in Kazakhstan therefore likely ranges between 120,000 and 180,000 tonnes per year, making it one of the most significant untreated industrial waste streams in Central Asia.[12][35] At European base oil prices of €1,140–€1,720 per tonne for Group I and Group II product, even a 50,000 tonne per year re-refining facility represents €57–€86 million in annual base oil revenue — a scale clearly warranting serious infrastructure investment.[16]

1.3 Purpose and Scope of This Report

This report was prepared by EEESEF — the Euro-Eurasia Environmental Science & Education Foundation. EEESEF focused on Kazakhstan's most significant untapped circular economy opportunity in its industrial sector. The report serves three purposes: first, to quantify the infrastructure gap with precision; second, to assess the technical and economic viability of inclined wall wiped film vacuum distillation as the preferred re-refining technology for Kazakhstan's conditions; and third, to provide actionable recommendations for government, industry, and international development partners.[35]

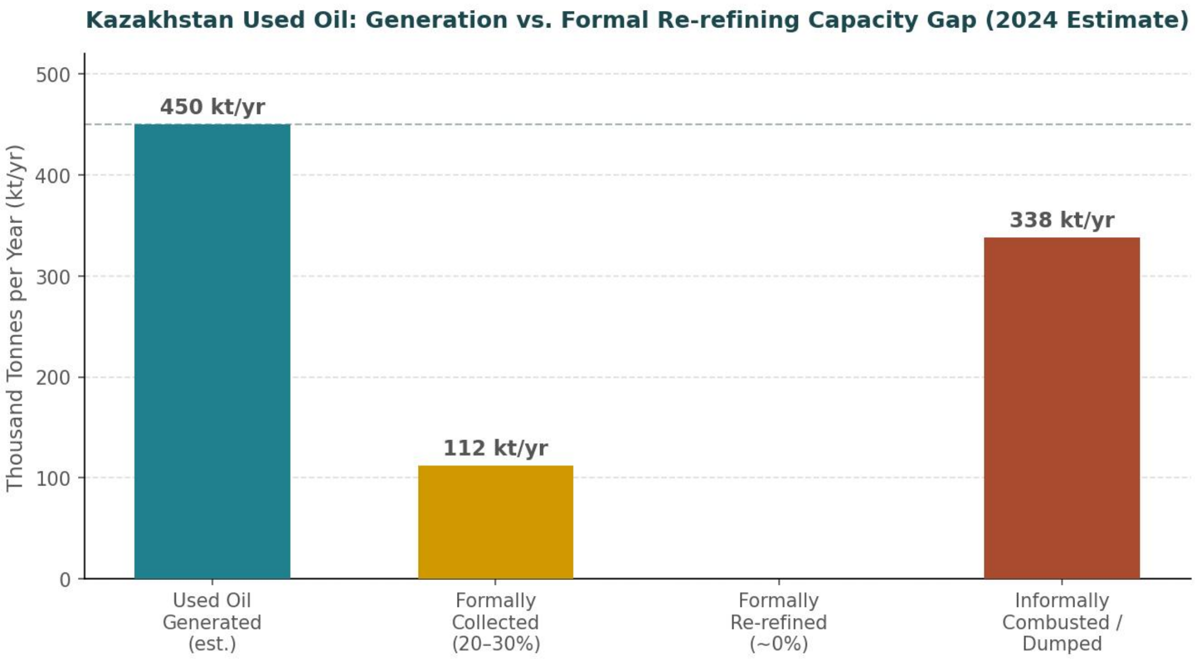

Figure 1: Kazakhstan Used Oil Generation vs. Formal Re-refining Capacity — The Infrastructure Gap (2024 Estimate)

2. Defining the Infrastructure Gap

2.1 Collection Rate Benchmarking

The formal used oil collection rate in Kazakhstan is estimated at only 20–30%, placing the country at the bottom quartile of global performance.[22][25] By comparison, Germany and France collect 78–82% of their used oil, the United States approximately 60%, and China — a developing economy — approximately 80%.[30][19] Even the Central Asian regional average of approximately 25% includes Kazakhstan's relatively better-organised industrial operators; actual collection from small and medium enterprises, independent service stations, and rural machinery operators is substantially lower.

The SWITCH-Asia EPR assessment (2025) confirmed that Kazakhstan's waste management system, while legally sophisticated, suffers from "insufficient domestic recycling capacity, requiring further infrastructure development" and "limited producer involvement in waste recycling processes."[25] The EPR system for oils and special fluids, which began in 2016, was transferred to state management in 2022, creating a period of institutional uncertainty that has further suppressed formal collection volumes.[25][24]

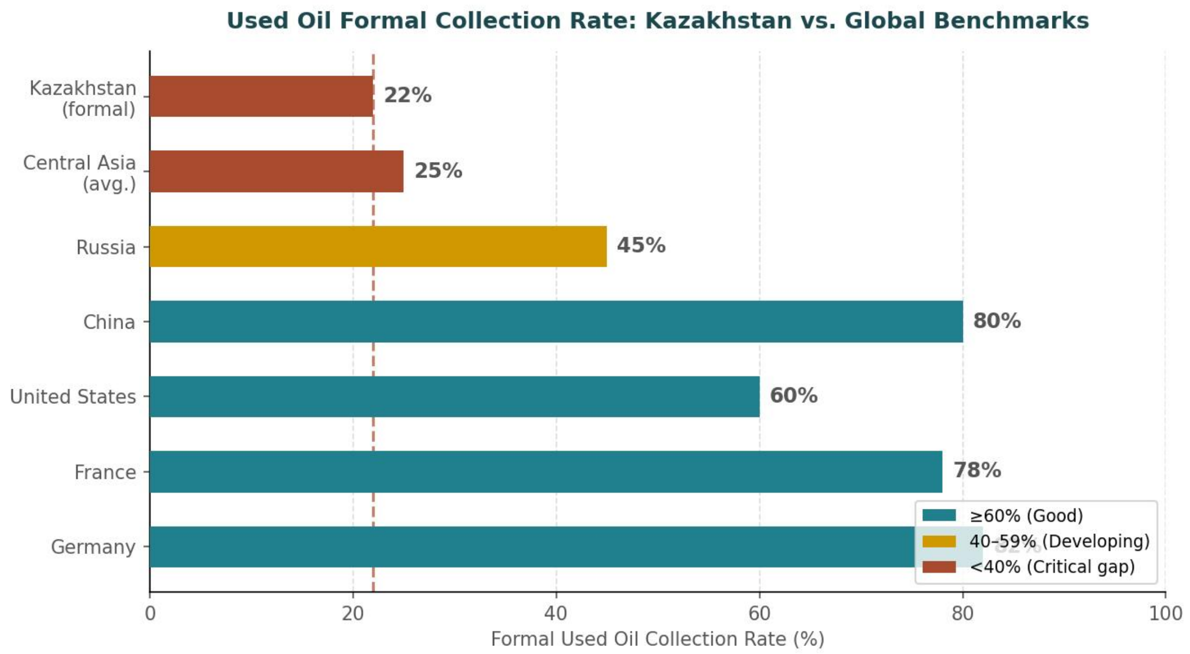

Figure 2: Used Oil Formal Collection Rate — Kazakhstan vs. Global Benchmarks

2.2 Current Disposal Pathways and Their Costs

Used oil in Kazakhstan flows through four principal disposal pathways, each with distinct economic and environmental consequences:

- Cement kilns and industrial boilers: Collected used oil is frequently sold to cement manufacturers and industrial boiler operators as a substitute fuel, typically at KZT 15,000–25,000 per tonne (approximately USD 30–55/tonne). This pathway recovers only heat value, destroying the far more valuable base oil molecules — a value destruction of approximately €700–€1,270 per tonne relative to re-refining output.[16][35]
- Illegal dumping and soil discharge: An estimated 25–40% of used oil generated outside major industrial sites is disposed of through illegal dumping on land, discharge into drainage systems, or use as a dust-suppressant on unpaved roads — a practice that is both illegal under the 2021 Environmental Code (Articles 341–342) and highly damaging to soil and groundwater systems.[23][25]
- Informal combustion in space heaters: Particularly in rural areas and small workshops, used oil is burned in informal space heaters — an uncontrolled combustion pathway that releases heavy metals, polycyclic aromatic hydrocarbons, and chlorinated compounds into the immediate environment.[5][22]
- Formal export or licensed incineration: A small fraction of used oil — primarily from major industrial operators with formal environmental compliance programs — is exported to Russia or CIS re-refining facilities, or incinerated at licensed hazardous waste facilities at significant cost.[20][24]

The economic cost of these pathways is enormous. Combusting an estimated 100,000–150,000 tonnes of used oil annually — which would otherwise yield approximately 90,000–135,000 tonnes of Group I/II base oil — destroys approximately €70–€190 million in product value per year (at €700–€1,270/tonne spread). This figure represents the annual economic loss attributable solely to the absence of re-refining infrastructure in Kazakhstan.[16][35]

Table 1: Comparison of Used Oil Disposal Pathways in Kazakhstan

Pathway	Typical Price Received	Base Oil Value Lost	Environmental Impact	Legal Status (KZ 2021)
Combustion (cement/boiler)	USD 30–55/t	€700–€1,270/t	Moderate — NOx, SOx, particulates	Legal (regulated)
Illegal dumping / road use	Zero / negative	€1,140–€1,720/t	Severe — soil/groundwater contamination	**Illegal — Art. 341–342**
Informal space heater combustion	Zero	€1,140–€1,720/t	Severe — HAPs, heavy metals	**Illegal — uncontrolled emission**
Formal export / incineration	Variable / costly	€1,140–€1,720/t	Low at destination	Legal (licensed)
Re-refining (target pathway)	€1,140–€1,720/t base oil revenue	€0 — full value captured	Low — 71–81% less CO_2 vs. virgin	Legal — preferred by Art. 329 hierarchy

2.3 Absence of Formal Re-refining Capacity

Kazakhstan currently has no operational Group I or Group II re-refining facility processing used lubricating oil at commercial scale, publicly verified, commercially scaled re-refining facility offering third-party processing. HILL Corporation has operated a used oil regeneration unit since 2015 with a stated capacity of 28,000 t/yr of base oils, primarily linked to in-house grease production, but its actual throughput, feedstock sourcing at scale, and commercial availability of output remain unverified in public literature.

The only re-refining activities in the country consist of small-scale, largely informal operations using outdated acid-clay or atmospheric distillation methods — technologies characterised by Steerkraft Industries' 2026 feasibility study as "basically hav[ing] no pollution prevention measures" and causing "severe environmental pollution."[12]

By contrast, Europe operates 26 re-refining plants in Western and Central Europe alone, with a combined used oil treatment capacity of 1.3 million tonnes per annum and a re-refined base oil output of 850,000 tonnes per year.[30][31] Russia, following its 2014 used oil disposal regulations, has developed a growing re-refining sector with several mid-scale facilities. Even China, despite its infrastructure challenges, achieved an 80–85% used oil recycling rate in 2022 through a network of licensed re-refining operations.[12]

The infrastructure gap is therefore total: Kazakhstan generates one of the largest used oil streams in Central Asia and processes essentially none of it through formal re-refining. This is the problem this report addresses.[20][25]

3. Global Re-Refined Base Oil Market Context

3.1 Market Size and CAGR Projections

The global re-refined base oil (RRBO) market was valued at approximately USD 3.4 billion in 2022 and is projected to reach USD 5.05–5.68 billion by 2027–2028, representing a compound annual growth rate of 6.26–6.82%.[1][2] Technavio projects USD 2.28 billion in absolute market growth between 2022 and 2027 at a 6.26% CAGR, while ResearchAndMarkets reports 6.82% CAGR growth reaching USD 5.05 billion by 2028.[1][2] The weighted central estimate of 6.5% CAGR places RRBO among the fastest-growing specialty chemical segments globally — growing approximately three times faster than the broader heavy fuel oil market (2.17% CAGR).[35]

Kazakhstan's lubricant market is growing in parallel, with IndexBox estimating a CAGR of approximately 4% for the Central Asian lubricants market through 2025.[21] This growth is driven by expanding vehicle fleets, increasing industrial output from mining and extractive operations, and infrastructure investment under Kazakhstan's 2025 and 2030 national development plans.[29] Each tonne of lubricant growth translates directly into additional used oil generation — strengthening the feedstock case for re-refining investment.[5]

Table 2: Global Re-Refined Base Oil Market Projections (2022–2028)

Source	Base Year Value	Forecast Year	Projected Value	CAGR (%)	Relevance to Kazakhstan
Technavio / PRNewswire [1]	USD 3.40B	2027	**~USD 5.68B**	6.26%	Global growth creates export opportunity
ResearchAndMarkets [2]	USD 3.40B	2028	**USD 5.05B**	6.82%	Rising base oil premium vs. fuel oil
Central estimate [35]	USD 3.40B	2027	**~USD 5.60B**	6.5%	Applied in KZ market projections
CA Lubricants Market [21]	~USD 0.45B	2025	**~USD 0.55B**	~4–5%	Direct feedstock growth driver

3.2 Why the Market Is Growing

Three structural forces drive RRBO market expansion globally, all of which are present or developing in Kazakhstan:

- Regulatory tightening: The EU's Waste Framework Directive targets 70–85% regeneration of collected waste oil by 2030, creating policy precedent that Kazakhstan's 2021 Environmental Code has explicitly begun to mirror through its waste hierarchy principle (Article 329) placing material recovery above energy recovery.[23][31]

- Price premium over fuel oil: Re-refined Group I base oil commands €700–€800 per tonne more than heavy fuel oil; Group II commands €1,000–€1,320 more. This spread has proven durable across oil price cycles, providing the fundamental economic argument for re-refining over combustion.[16][35]
- OEM and ESG acceptance: Original equipment manufacturers now routinely approve re-refined base oils for warranty coverage, while ESG-conscious industrial operators in Kazakhstan's mining and oil sectors are increasingly required by international lenders and bond covenants to demonstrate responsible waste management practices.[5][29]

4. Re-Refining Technology Landscape

4.1 Overview of Available Technologies

The academic and industrial literature identifies seven principal technology pathways for used oil re-refining, each with distinct advantages, limitations, chemical inputs, and waste outputs.[6][8][32] The following summary draws on the comprehensive review by Sarkar et al. (2023), the comparative analysis in Al Mamun et al. (2024), and the independent technology comparison prepared by Steerkraft Industries (2026):[5][8][12]

Table 3: Comparative Analysis of Used Oil Re-Refining Technologies

Technology	Base Oil Yield	Chemicals Required	Waste Generated	Env. Profile	Capex Level	KZ Suitability
Acid-Clay Process	55–65%	H_2SO_4, clay	Acid slag, waste clay, SO_2	Very Poor	Low	Not recommended — banned trend
Distillation + Clay	65–75%	Clay (large volumes)	Waste clay	Poor	Low-Med	Outdated — environmental issues
Distillation + Hydrogenation	80–85%	H_2 (high purity)	Minimal	Good	Very High	Technically superior but H_2 supply challenge
Molecular / Short-Path Distillation	72–80%	None	Minimal	Very Good	High	Strong — but sensitivity to feedstock
Solvent Refining (NMP)	70–78%	NMP solvent (recycled)	Minimal	Good	Medium	Good option but solvent handling risk
Membrane Separation	60–70%	None	Minimal	Very Good	High	Not yet proven at industrial scale in CIS
Vacuum Wiped Film Distillation ★	**84–90%**	NONE	NONE	**Excellent**	Medium	**★ Recommended — see Section 5**

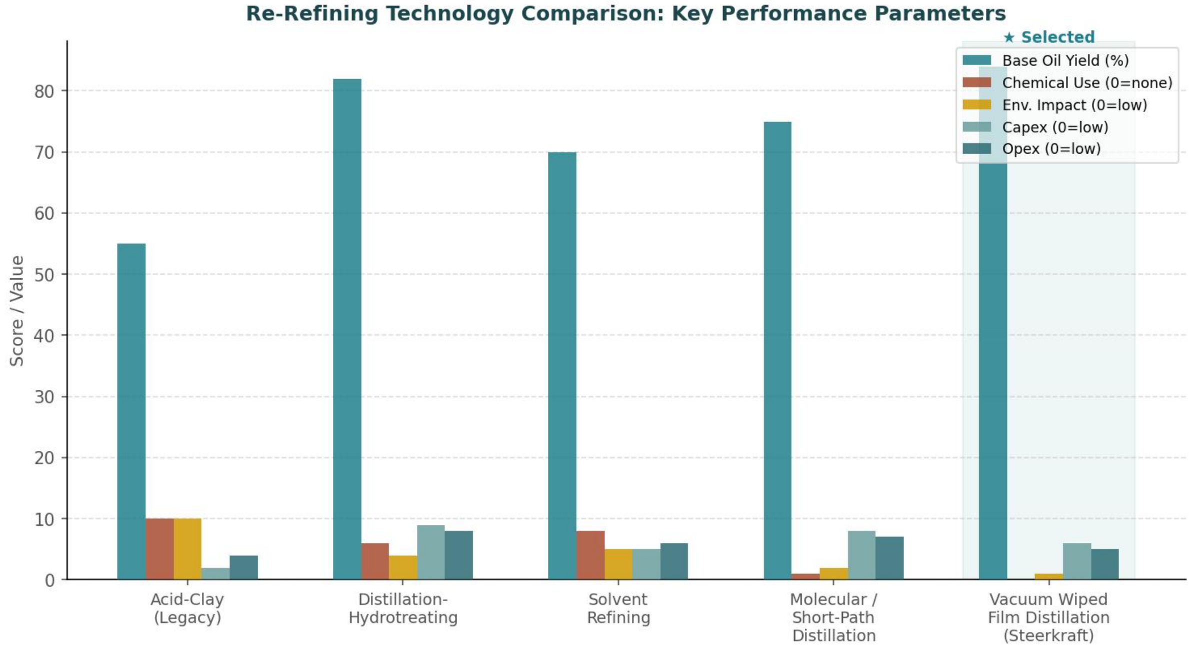

Figure 3: Re-Refining Technology Comparison — Key Performance Parameters (Selected metrics; lower is better for chemical use, environmental impact, and capex)

4.2 Technology Selection Rationale for Kazakhstan

Several factors unique to Kazakhstan's context influence technology selection:[12][22]

- Feedstock heterogeneity: Kazakhstan's used oil stream is dominated by heavy industrial and mining lubricants with potentially high metal content from drilling operations, mixed with automotive crankcase oils. This feedstock complexity favours technologies with robust tolerance to contamination — a characteristic of vacuum distillation's pre-treatment and fractionation stages.[12][15]
- Hydrogen supply limitations: The distillation-hydrogenation process — technically superior in product quality — requires a reliable high-purity hydrogen supply. Kazakhstan's hydrogen infrastructure is nascent and geographically concentrated. This constraint significantly limits the practical deployment of hydrogenation processes outside Atyrau or Pavlodar refinery environments.[29]
- Chemical waste regulations: The Environmental Code 2021 imposes stringent requirements on acid waste, used clay disposal, and chemical effluents from industrial facilities. Technologies requiring acid or large clay volumes create significant ongoing compliance costs and liability.[23]
- Capital efficiency: Kazakhstan's re-refining industry must attract private capital in a market with no track record. Technologies with lower capital requirements and faster payback periods are strongly preferred for first-mover facilities.[12]

On all four criteria, inclined wall wiped film vacuum distillation — the technology deployed in the Steerkraft Industries reference facility design for Almaty — ranks as the most appropriate technology for Kazakhstan's initial re-refining infrastructure development.[12][35]

5. Vacuum Distillation — The Selected Technology

5.1 Principles of Inclined Wall Wiped Film Vacuum Distillation

Vacuum distillation, in its most advanced form as applied to used oil re-refining, operates on the fundamental principle that hydrocarbon molecules can be separated by their differential volatility under controlled negative pressure conditions, without reaching the temperatures that cause thermal cracking or polymerisation of the valuable base oil fraction.[3][6] The "inclined wall wiped film" variant — also described in literature as a wiped film evaporator (WFE) or thin film evaporator — enhances this principle by spreading the oil feedstock into an extremely thin film (0.1–2 mm) across a heated inclined surface, maximising heat transfer area while minimising residence time.[9][33]

The physics of the process are well-established in peer-reviewed literature. Saleem and Karim (2020) describe the mechanism precisely: "The whole process consists of dehydration, gas oil evaporation, thin wiped film evaporation and clay treatment. The produced base oils are in group I through determination of sulfur contents, percentage of saturate compounds and viscosity indexes."[3] CEP Technology — a leading Western re-refining technology provider — independently confirms: "A wiped film evaporator is used to separate the lube oil from the additives and other contaminants... The wiped film evaporator operates under vacuum so that the distillation can take place below the temperature that would cause the lube oil to crack."[10]

Under the specific conditions of the Steerkraft reference design, the vacuum tower operates at -0.099 MPa gauge pressure (approaching full vacuum) with a thermal oil furnace outlet temperature of 320°C — conditions that ensure complete separation of light distillate fractions, lubricating oil fractions, and residual heavy asphaltenes without chemical intervention.[12]

5.2 Process Flow: Step by Step

The complete process flow of the reference facility, as described in the Steerkraft Industries (2026) technical feasibility document and corroborated by independent academic and industrial sources, consists of six integrated stages:[12][11][3]

- Stage 1 — Raw Material Intake and Classification: Incoming used oil arrives by tanker truck, is weighed on electronic scales, sampled for laboratory analysis of viscosity, water content, metal content, and contamination profile, and directed to appropriate raw material tanks (2 × 1,000 m³) according to quality grade.[12]
- Stage 2 — Pre-heating and Dewatering: Raw material is pumped to the preheating tower (Φ2000×3800 mm), passing through heat exchangers for cyclic heat exchange at temperatures controlled below 120°C. Water and volatile light components (gasoline fraction) are removed and condensed; non-condensable gas is directed through a flame arrestor to the heating furnace as self-fuel.[12]

- Stage 3 — De-lighting Tower: The dewatered feedstock is pumped to the de-lighting tower, heated by circulation through the heating furnace to approximately 260°C for deep removal of light-end hydrocarbons (diesel fraction). Generated light components condense and are captured; non-condensable gas feeds the furnace.[12]
- Stage 4 — Vacuum Distillation (Core Process): The de-lighted raw material enters the vacuum tower (2 × Φ2200×3800 mm) at -0.099 MPa. Heated by thermal oil furnace to 320°C, the oil and gas mixture passes through the purification tower (packing changes direction, blocking impurities) then into the fractionation tower where different temperature fractions yield 150SN base oil, 350SN base oil, and residual oil. Non-condensable gas returns to furnace. Residual oil (heavy asphaltenes) is directed to storage for sale to asphalt processing plants.[12]
- Stage 5 — Heat Exchange and Cooling: Product fractions pass through heat exchangers (recovering heat to pre-warm incoming feedstock, maximising energy efficiency) and quench coolers (circulating water system, 300 m³ pool) before entering buffer tanks.[12]
- Stage 6 — Product Storage and Dispatch: 150SN and 350SN base oils are pumped to product storage tanks (2 × 1,000 m³) for quality verification and dispatch. Residual oil to storage (300 m³). Furnace fuel oil to self-use.[12]

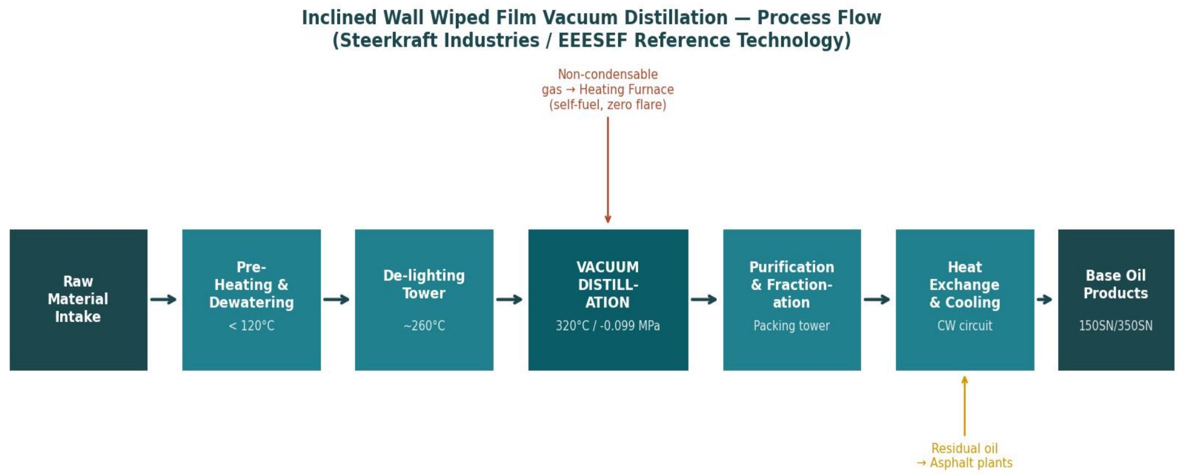

Figure 4: Inclined Wall Wiped Film Vacuum Distillation — Integrated Process Flow (Steerkraft Industries / EEESEF Reference Technology, Almaty)

5.3 No Chemicals, No Waste: Environmental Credentials

The most important environmental characteristic of vacuum distillation is its complete elimination of chemical inputs and chemical waste streams — a claim that is fully supported by independent peer-reviewed evidence.[3][4][6]

A German patent (DE3042094A1) describing the short-path distillation precursor technology explicitly states: "The inventive method... does not require any chemicals and... uses a combined effect from vacuum and elevated temperature."[6] This is the fundamental physical basis: separation is achieved by differential volatility under pressure, not by chemical reaction, neutralisation, or adsorption.[6][33]

Oyegbanren et al. (2025) — in a recent experimental validation study — confirm that vacuum distillation combined with minimal clay post-treatment "effectively removes a broad spectrum of contaminants; including water, light hydrocarbons, wear metals, and oxidation products" yielding base oil with "physicochemical properties... that are on par with virgin base oil."[4]

In the Steerkraft reference facility, waste generation is explicitly quantified in the environmental chapter: "No solid waste is generated during the production process of this project." The only effluents are equipment and floor washing water (treated on-site), domestic wastewater (treated to standard), and non-condensable gas (combusted as furnace fuel, meeting GB13271-2014 stack emissions standards).[12]

This is a critically important distinction for Kazakhstan. Under the Environmental Code 2021, Article 341–342 classify used oils as hazardous waste with strict handling requirements. A facility generating acid slag, waste clay, or chemical effluents would face significant ongoing compliance costs and environmental liability. Vacuum distillation produces none of these outputs.[23][24]

5.4 Product Yield and Quality

The reference 30,000 t/yr facility produces the following annual output from 30,000 tonnes of waste mineral oil feedstock:[12]

Table 4: Product Scheme — 30,000 t/yr Reference Facility (Almaty)

Product	Annual Volume (t/yr)	Disposition	Market Value Ref.
150SN Base Oil (Group I)	18,000	Commercial sale	≈ CNY 7,000/t (≈ USD 960/t)
350SN Base Oil (Group I)	9,000	Commercial sale	≈ CNY 8,500/t (≈ USD 1,165/t)
Residual Oil (asphaltene)	1,500	Sale to asphalt plants	≈ CNY 3,000/t
Furnace Fuel Oil (distillate)	1,500	Self-use (process energy)	Internal — reduces gas costs
TOTAL OUTPUT	30,000	100% utilisation	Zero waste to disposal

The base oil yield of 90% (27,000 tonnes of saleable base oil from 30,000 tonnes input) is consistent with — and slightly exceeds — the range reported in peer-reviewed literature for thin wiped film evaporation processes. The OSTI/Booth Oil study reported 70–90% lube oil distillate recovery depending on feedstock non-volatile residue content.[9] The KTI distillation-hydrogenation process achieves 80–85% recovery but requires hydrogen.[6] The vacuum wiped film process achieves 84–90% without any chemical input.[3][12]

5.5 Comparison with Other Leading Processes

Independent academic validation specifically for the thin wiped film evaporation approach is provided by multiple peer-reviewed sources. Saleem and Karim (2020) tested the process on Iraqi used lubricating oils and confirmed Group I base oil production meeting most ASTM property standards, with significant reductions in wear metal content, acid number, and colour.[3] The STP Re-refining Process — a Western industrial standard deploying wiped film evaporation as its core separation step — explicitly states: "STP Re-refining process does not release harmful or pollutant wastes to be disposed and is therefore environment friendly."[11]

Li et al. (2019), reviewing green refining approaches from a Chinese industrial perspective, confirm that vacuum distillation-based processes achieve total recovery rates of approximately 63–85% of saleable product with minimal environmental footprint — performing significantly better than acid-clay alternatives at comparable or lower capital cost.[14]

6. Reference Facility: 30,000 t/yr Almaty Design

6.1 Facility Specifications

The reference facility analysed in this report is based on the Technical Feasibility Reference prepared by Steerkraft Industries Limited (Hong Kong) in January 2026, describing a 30,000 tonne per annum waste mineral oil comprehensive utilisation project designed for deployment in Almaty, Kazakhstan.[12] Steerkraft is a UK-Hong Kong-Kazakhstan-China industrial group with confirmed operational experience in several re-refineries in China. — all currently in production.[12]

The Almaty facility is designed for a 13,333 m² site (20 mu), with the following headline specifications:

- Annual processing capacity: 30,000 tonnes of waste mineral oil feedstock[12]
- Annual operating period: 300 days (7,200 hours), four-shift three-rotation system[12]
- Core technology: Inclined wall wiped film vacuum distillation (vacuum tower at -0.099 MPa, 320°C)[12]
- Total installed electrical capacity: 400 kW (operating load: 200 kW)[12]
- Water consumption: 9,360 m³/yr (municipal supply plus circulating water system)[12]
- Workforce: 20 persons (management, R&D laboratory, production, logistics)[12]
- Construction period: 12 months (June 2026 to May 2027 commissioning per reference schedule)[12]

6.2 Main Equipment List

The facility employs a fully integrated distillation train with heat recovery, vacuum generation, and DCS process control. Key process equipment items are listed in Table 5.[12]

Table 5: Principal Process Equipment — 30,000 t/yr Reference Facility

No.	Equipment	Qty	Key Specification	Operating Conditions
1	Preheating Tower	1	Φ2000×3800 mm	T ≤ 120°C / P = 0.05 MPa
2	De-lighting Tower	1	Φ2000×3800 mm	T ≈ 260°C / P = 0.05 MPa
3	Vacuum Tower (core unit)	2	Φ2200×3800 mm	T ≤ 320°C / P = -0.099 MPa
4	Purification Tower	2	Φ1000×3000 mm	T = 320°C / P = 0.05 MPa
5	Vacuum Purification Tower	2	Φ1400×5200 mm	T = 320°C / P = 0.05 MPa
6	Fractionation Tower	1	Φ1200×9000 mm	T = 320°C / P = 0.05 MPa
7	Heating Furnaces	2	300,000 kcal/h each	Fuel: non-condensable gas + furnace fuel oil
8	Vacuum Pump Unit	1	JZJ2B-1200-2.2.1B	P = -0.099 MPa
9	Raw Material Storage	2	V = 1,000 m³ each	T = 35°C / Atmospheric
10	Product Base Oil Storage	2	V = 1,000 m³ each	Ambient / Atmospheric

6.3 Raw Material Supply and Site Requirements

The facility's 30,000 t/yr feedstock requirement represents approximately 17–25% of Kazakhstan's estimated annual used oil generation of 120,000–180,000 tonnes — a significant but entirely achievable fraction of the available feedstock.[12][22] Three primary collection channels supply the facility: used oil from tank cleaning at industrial sites and ports; lubricating oil replaced during equipment maintenance at mining and manufacturing enterprises; and waste lubricating oil from commercial vehicle service centres.[12]

Site requirements are standard for a light industrial facility: stable geological conditions, municipal water supply (16 m^3/h maximum instantaneous demand), dual 10kV power supply substations (400 kW installed capacity), and adequate fire safety distances from residential and commercial areas.[12] The Almaty site at approximately 13,333 m^2 (20 mu) is consistent with available industrial plots in Almaty's designated industrial zones, where Kazakhstan's EPR operator Jasyl Damu JSC is actively developing waste management infrastructure.[25][26]

7. Economic Analysis

7.1 Revenue Model and Price Assumptions

Revenue is generated from two saleable products: 150SN base oil at CNY 7,000/tonne (approximately USD 960/t at current rates) and 350SN base oil at CNY 8,500/tonne (approximately USD 1,165/t).[12] A small additional revenue stream flows from residual oil sold to asphalt processors at CNY 3,000/tonne.[12] Furnace fuel oil is consumed internally, reducing natural gas purchase costs.

These prices are conservative relative to European benchmarks. Klenert et al. (2024) report European Group I base oil prices of €1,140/tonne (approximately USD 1,240/t) and Group II prices of €1,720/tonne (approximately USD 1,870/t) as of late 2022.[16] Applying a standard 10–20% CIS discount to European prices yields Central Asian Group I prices of €910–€1,025/tonne and Group II prices of €1,375–€1,545/tonne — above the reference facility's CNY-denominated assumptions, suggesting additional revenue upside at full production.[16][35]

7.2 Investment and Cost Structure

The total project investment is CNY 50 million (approximately USD 6.85 million at current rates), comprising CNY 47 million in construction investment and CNY 3 million in working capital.[12] Construction investment breaks down as follows:

- Equipment procurement: CNY 20 million (50% of fixed assets)[12]
- Civil engineering: CNY 10 million (25% of fixed assets)[12]
- Installation engineering: CNY 5 million (12.5% of fixed assets)[12]
- Automation and control (DCS): CNY 5 million (12.5% of fixed assets)[12]
- Deferred assets (permits, design, environmental assessment): CNY 2 million[12]
- Contingency (5% of engineering + other costs): CNY 5 million[12]

Raw material cost is CNY 3,500/tonne of waste mineral oil input (approximately USD 480/t) conservativelly but in reality is much lower — the price paid to used oil collectors and aggregators.[12] Utility costs are based on local Almaty pricing: fresh water at CNY 5.6/tonne, electricity at CNY 0.79/kWh, natural gas at CNY 3.5/m³.[12] Annual electricity consumption is 1.44×10^4 kWh and annual water consumption 9,360 m³.[12]

7.3 Financial Performance Indicators

The Steerkraft feasibility analysis reports the following headline financial metrics for the reference 30,000 t/yr facility operating at full capacity:[12]

- Annual operating revenue: CNY 207 million (approximately USD 28.4 million)
- Annual average EBIT: CNY 58.17 million (approximately USD 7.97 million)
- Annual average after-tax net profit: CNY 43.63 million (approximately USD 5.98 million)
- After-tax internal rate of return (IRR): 96%
- After-tax financial net present value: CNY 191.85 million (approximately USD 26.3 million)
- Dynamic investment payback period (including construction): 2.2 years
- Total investment return rate: 116.35%
- Return on equity: 87.26%
- Break-even point: 33.01% of production capacity

The 33% break-even point is particularly significant: the facility generates profit at one-third of its design capacity, providing extraordinary resilience to feedstock supply variability and market price fluctuations during ramp-up.[12] For a first-of-its-kind facility in Kazakhstan, this risk profile is highly favourable.

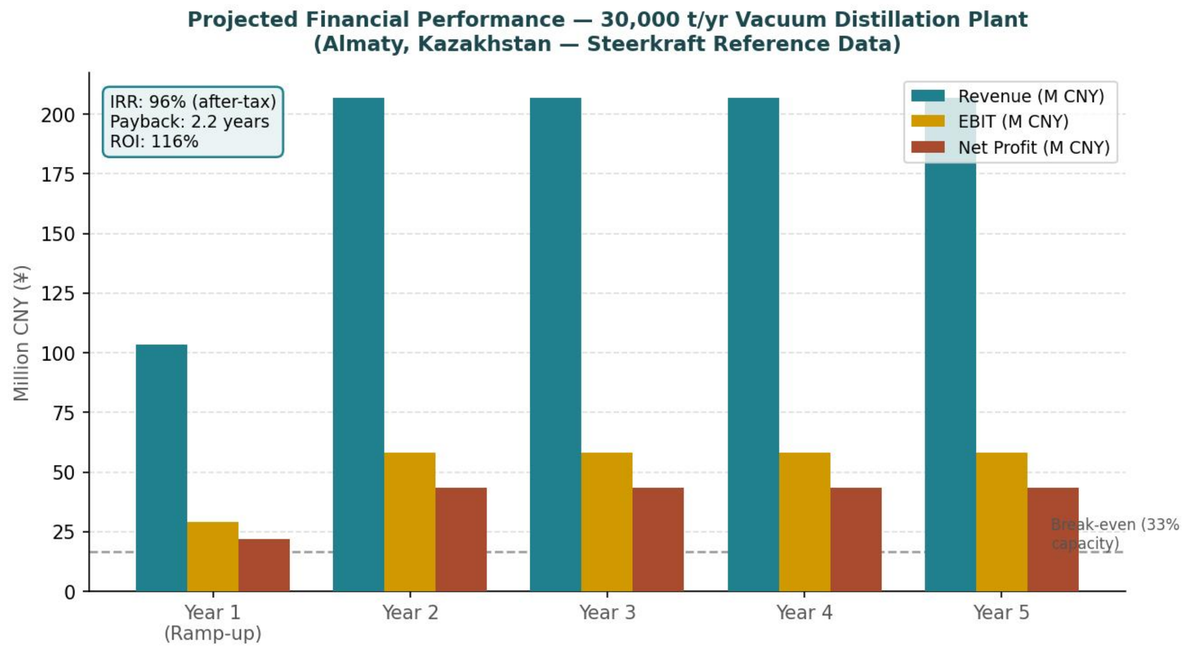

Figure 5: Projected Financial Performance — 30,000 t/yr Vacuum Distillation Plant (Almaty Reference Design, Steerkraft Industries 2026)

7.4 Scaling to Kazakhstan's Full Feedstock Potential

Kazakhstan's 120,000–180,000 tonne annual used oil generation supports a realistic maximum re-refining capacity of six 30,000 t/yr facilities — a CNY 300 million (approximately USD 41 million) total capital investment generating CNY 1.24 billion (approximately USD 170 million) in annual revenue and CNY 262 million (approximately USD 36 million) in annual net profit.[12][35]

A realistic phased scenario targets formal collection of 50% of used oil generation (approximately 75,000 tonnes) through infrastructure investment, supporting two to three mid-scale re-refining facilities. At this scale, Kazakhstan would produce approximately 67,500 tonnes of re-refined base oil annually, capturing a market share of approximately 1.2% of the global RRBO market by 2030 — a meaningful and commercially credible initial position.[1][2][35]

Table 6: Kazakhstan Re-Refining Scale-Up Scenarios (2027–2035)

Scenario	Feedstock Processed	No. of Facilities	Total Capex	Annual Revenue	Annual Net Profit	Base Oil Output
Phase 1 (2026–2027)	30,000 t	1	CNY 50M	CNY 207M	**CNY 43.6M**	27,000 t
Phase 2 (2028–2030)	90,000 t	3	CNY 150M	CNY 621M	**CNY 131M**	81,000 t
Phase 3 (2031–2035)	150,000 t	5	CNY 250M	CNY 1.04B	**CNY 218M**	135,000 t
Full Potential (2040)	180,000 t	6	CNY 300M	CNY 1.24B	**CNY 262M**	162,000 t

8. Environmental and GHG Impact Assessment

8.1 Life Cycle GHG Savings

Life cycle assessment studies consistently demonstrate a transformative greenhouse gas advantage of re-refining over combustion. Grice et al. (cited in U.S. DOE, 2020) find that the carbon footprint of re-refining is 81% lower than production of fresh virgin oil from base stocks.[17] GEIR — the Group of European Used Oil Regenerators — independently calculates CO_2 emission reductions of up to 71% for re-refined versus virgin-origin base stocks.[31] At the policy scale, Klenert et al. (2024) project that increasing EU regeneration from 61% to 85% would avoid 1.7 million tonnes of CO_2 -equivalent over 2024–2045.[16]

Applying the 71–81% CO_2 reduction figure to Kazakhstan's context: combusting 100,000 tonnes of used oil generates approximately 300,000 tonnes of CO_2 -equivalent (versus 57,000–87,000 tonnes if that oil were re-refined and used as base oil), a net avoidance of 213,000–243,000 tonnes of CO_2 -equivalent per 100,000 tonnes shifted from combustion to re-refining.[16][31] At the full 120,000–180,000 t/yr potential, Kazakhstan's re-refining programme would avoid approximately 320,000–440,000 tonnes of CO_2 -equivalent annually — a meaningful contribution to the country's 2060 carbon neutrality target.[29]

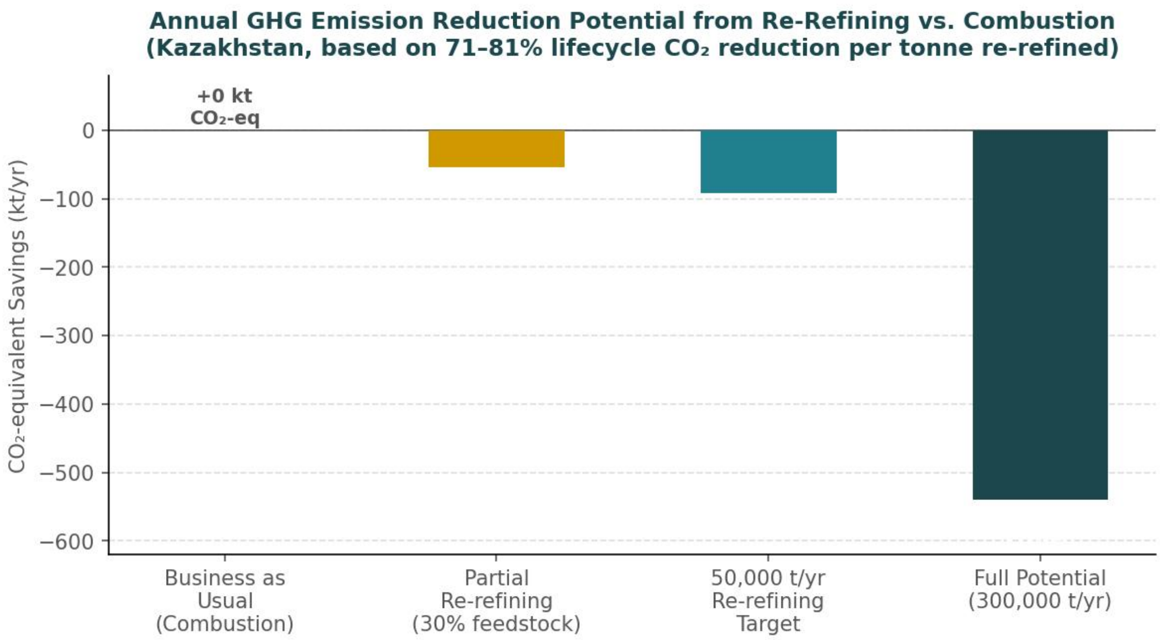

Figure 6: Annual GHG Emission Reduction Potential — Kazakhstan Re-Refining Scenarios vs. Business-as-Usual Combustion (Based on 71–81% lifecycle CO_2 reduction per tonne re-refined)

8.2 Soil and Water Protection Benefits

The environmental protection case for re-refining in Kazakhstan extends well beyond greenhouse gas accounting. Used oil contains heavy metals (lead, zinc, cadmium, chromium), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and spent additives — all of which, when illegally dumped or burned informally, contaminate soil and groundwater systems.[5][23]

Kazakhstan's Chambers & Partners (2025) assessment notes that illegal dumping of used oil creates liability under the Environmental Code for soil remediation costs — costs that have historically been borne by the state rather than the generator.[24] The SWITCH-Asia (2025) report confirms that 5,534 unauthorised waste disposal sites were detected in Kazakhstan in 2023 alone, of which used oil contamination forms a significant fraction.[25] A formal re-refining infrastructure that offers collectors economic incentives to deliver used oil for processing — rather than dump it illegally — directly addresses this pathway.[26]

8.3 Alignment with KazETS Carbon Trading

Kazakhstan's Emissions Trading System (KazETS) has been operational since 2013 and covers the oil and gas sector.[29] Re-refining facilities generate verifiable greenhouse gas reductions that — under Article 6 of the Paris Agreement and Kazakhstan's nationally determined contribution framework — may qualify for carbon credit generation. As the KazETS develops its methodology for waste sector credits, re-refining projects positioned at the intersection of hazardous waste management and verified GHG reduction will be well-placed to access carbon revenue streams supplementary to product revenues.[24][29]

9. Regulatory and Policy Framework

9.1 Environmental Code 2021

Kazakhstan's Environmental Code of 2021 (Law No. 400-VI ZRK) provides the foundational legal architecture for used oil re-refining development.[23] Several provisions are particularly relevant:

- Article 329 — Waste Hierarchy: Establishes a legally binding waste hierarchy placing material recovery (re-refining) above energy recovery (combustion) for waste oils. This article provides the legal basis for policy preferences, permitting advantages, and extended producer responsibility obligations that favour re-refining investments.[23]
- Articles 341–342 — Hazardous Waste Classification: Classifies used mineral oils as hazardous waste, imposing mandatory manifesting, transport licensing, and authorised treatment requirements. This classification creates a legal imperative for generators to use licensed treatment facilities — generating captive feedstock demand for formal re-refiners.[23]
- Article 332 — Extended Producer Responsibility: Requires oil product producers and importers to fund used oil collection and management infrastructure, creating a financial mechanism for subsidising collection logistics independent of product price.[23][24]
- Articles 344–347 — Hazardous Waste Management Requirements: Impose facility design, operational, monitoring, and reporting standards on hazardous waste management facilities, including used oil re-refineries. These standards — while demanding — are fully met by the reference facility design.[12][23]
- Landfill ban (since 2016): Kazakhstan banned the landfill disposal of waste oils from 2016, predating even the 2021 Code — a foundation that forces waste oil into either formal treatment or illegal disposal channels.[22][23]

9.2 Extended Producer Responsibility (EPR)

The EPR system for oils and special fluids was established in Kazakhstan in 2016 and covers collection and disposal obligations for lubricant manufacturers and importers.[25] Since January 2022, EPR operations have been managed by Jasyl Damu JSC under the Environmental Code's Article 388, which empowers the EPR operator to fund collection infrastructure, sorting, processing, and recycling facilities.[25]

The transfer of EPR operations to state management in 2022 created institutional disruption but also an opportunity: Jasyl Damu JSC now has the mandate and the financial resources — funded by EPR fees — to contract with re-refining facilities for used oil offtake, providing guaranteed feedstock supply contracts that significantly de-risk private investment in re-refining infrastructure.[25][26] EEESEF recommends that international development partners and the Government of Kazakhstan engage with Jasyl Damu JSC specifically to establish a long-term offtake framework for re-refined base oils.

9.3 Green Economy Concept 2050

Kazakhstan's Concept for the Transition to a Green Economy targets 40% municipal waste recycling and 44% industrial waste recycling by 2024, with used oil explicitly listed as a recyclable industrial waste type.[22] The country's 2060 carbon neutrality commitment requires significant reductions in industrial waste combustion — a category that includes informal used oil burning.[29] The 2024 government announcement of plans to construct 37 new waste plants while modernising 8 existing facilities signals strong state commitment to waste processing infrastructure investment.[26]

Re-refining sits precisely at the intersection of all three green economy objectives: industrial waste recycling, carbon reduction, and resource efficiency. Kazakhstan's Green Economy agenda provides the political mandate and, increasingly, the financial mechanisms — through Jasyl Damu JSC, KazETS, and international green finance instruments — to support re-refining infrastructure at scale.[25][26][29]

10. Strategic Recommendations

10.1 Priority Infrastructure Investments

EEESEF recommends a three-phase infrastructure deployment strategy calibrated to Kazakhstan's feedstock availability, regulatory readiness, and investment risk profile:

- Immediate Priority (2026–2027): Establish one pilot-scale re-refining facility of 30,000 t/yr using inclined wall wiped film vacuum distillation technology in the Almaty region — the country's largest used oil generation centre. This facility should be co-located with the existing used oil collection infrastructure serving Almaty's vehicle service sector and the nearby Balkhash mining complex. The reference Steerkraft Industries design provides a proven template.[12][35]
- Medium-Term (2028–2030): Develop secondary facilities in the Atyrau and Pavlodar refinery corridors, where the Tengiz, Kashagan, and Pavlodar refinery operations generate the densest industrial used oil streams. A 30,000 t/yr facility co-located with each refinery would benefit from existing infrastructure, captive feedstock, and proximity to base oil blending facilities.[18][27]
- Long-Term (2031–2035): Develop used oil collection logistics infrastructure — mandatory collection points at service stations, lubricant retailer take-back programs, and industrial waste oil manifesting systems under EPR operator oversight — to increase formal collection rates from 20–30% toward the 60–70% range achieved by Russia and upper-middle-income economies.[20][25]
- Export pathway: Establish Kazakhstan as a re-refined base oil exporter to the CIS market, leveraging the country's central position in the CIS trade network and the EAEU free trade framework to supply re-refined Group I/II base oils to markets currently importing from European or Russian sources.[20][29]

10.2 Institutional and Regulatory Actions

- Mandatory EPR offtake contracts: Direct Jasyl Damu JSC to establish minimum-price offtake contracts with licensed re-refiners, providing revenue certainty that justifies private investment.[25][26]
- Investment tax incentives: Establish 5-year corporate income tax exemptions for greenfield re-refining facilities under Kazakhstan's Special Economic Zone framework, consistent with incentives available to other priority industrial sectors.[24]
- Licensing streamlining: Develop a dedicated fast-track permitting pathway for re-refining facilities under the Environmental Code's hazardous waste facility licensing regime, with EEESEF providing independent technical review support.[23][35]
- Public procurement preference: Mandate that government vehicle fleets, mining state enterprises, and KazMunayGas subsidiaries preferentially purchase re-refined lubricants — providing anchor demand for domestic re-refinery output.[18][22]

- Penalties for illegal disposal: Increase enforcement of Articles 341–342 penalties for illegal used oil dumping, with revenues directed to the EPR fund for collection infrastructure investment.[23][24]

10.3 EEESEF Role and Research Agenda

As the Euro-Eurasia Environmental Science & Education Foundation, EEESEF is uniquely positioned at the intersection of independent scientific research, policy advisory, and industry engagement to advance Kazakhstan's used oil re-refining agenda. EEESEF's recommended research program for 2026–2028 encompasses:

- Feedstock characterisation study: Systematic laboratory analysis of used oil samples from Kazakhstan's three principal generating sectors (automotive, industrial/mining, refinery process oils) to establish precise feedstock quality parameters and technology optimisation requirements for local conditions.[12][5]
- Environmental baseline assessment: Soil and groundwater contamination mapping in industrial zones where illegal used oil disposal is prevalent — establishing the environmental damage baseline against which re-refining infrastructure benefits can be quantified.[22][25]
- Policy modelling: Economic modelling of EPR fee structures, tax incentive scenarios, and carbon credit valuations under KazETS to identify the optimal policy mix for incentivising private re-refining investment.[24][29]
- Technology transfer facilitation: EEESEF will serve as an independent technical intermediary between international re-refining technology providers and Kazakhstani industrial investors, providing technology assessment, due diligence support, and operational monitoring under internationally recognised environmental standards.[35]

11. Conclusions

Kazakhstan presents one of the most compelling and under-exploited used oil re-refining opportunities in the world. The country generates an estimated 120,000–180,000 tonnes of used lubricating oil annually — yet processes essentially none of it through formal re-refining. The economic loss from this infrastructure gap exceeds €70–€190 million per year in foregone base oil value. The environmental cost — in soil contamination, groundwater pollution, and greenhouse gas emissions — is additional and substantial.[35][16]

The technology to close this gap exists, is proven at industrial scale, and is appropriate for Kazakhstan's conditions. Inclined wall wiped film vacuum distillation — the process deployed in the reference 30,000 t/yr Steerkraft Industries facility design for Almaty — achieves 84–90% base oil recovery from waste mineral oil without any chemical inputs, without generating chemical waste, and with complete non-condensable gas self-consumption as furnace fuel. The technology performance underlying these claims — the 84–90% recovery, the absence of chemical inputs and chemical waste, and the self-consumption of non-condensable gas — is corroborated by multiple independent peer-reviewed studies of thin-film evaporation and is consistent with the documented use of this process family in China, Germany, and the United States.[3][9][10][12]

The projected economic case is equally compelling. The Steerkraft reference design projects a 96% after-tax IRR, a 2.2-year payback period, and a break-even point at only 33% of capacity — figures that, if confirmed by the independent validation this report calls for, present a risk profile capable of attracting private capital even in the absence of policy support. With appropriate EPR offtake contracts, tax incentives, and regulatory streamlining, the investment case becomes overwhelming.[12]

Kazakhstan's Environmental Code 2021 provides the legal foundation — Article 329's waste hierarchy, Article 332's EPR obligations, and Articles 341–347's hazardous waste management requirements collectively mandate the development of re-refining capacity. The government's Green Economy 2050 agenda provides the political will. The feedstock is abundant. The technology is proven. The projected economics are exceptional, and warrant the independent validation that would confirm them.[23][29]

EEESEF's inaugural Technical Report concludes that the used oil re-refining infrastructure gap in Kazakhstan is the country's single most actionable circular economy opportunity — one that can deliver measurable environmental, economic, and social returns within the current policy cycle. EEESEF commits to supporting its systematic, evidence-based closure.[35]

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APPROVAL FOR PUBLICATION

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