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EEESEF - SUSTAINABILITY GAP ANALYSIS (SGA) SERIES

Industrial Waste Management Policy and 2021 Environmental Code Compliance Realities

Hazardous Fluid Circular Economy Gaps

A Macro-Level Policy Analysis & Compliance Gap Assessment

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Abstract

This paper presents a comprehensive macro-level policy analysis examining the structural alignment between industrial hazardous-fluid management practices in Kazakhstan and the statutory mandates of the Ecological Code of the Republic of Kazakhstan No. 400-VI of 2 January 2021. It focuses on three hazardous-fluid streams: waste mineral oils and lubricants; oil sludge and oil-contaminated liquids; and refinery effluents, process waters, and related industrial chemical fluids. The analysis evaluates these streams through a non-commercial circular-economy compliance lens, connecting legal obligations to regional waste-fluid inventories, current disposal models, lifecycle tracking deficiencies, and institutional bottlenecks. The central finding is that Kazakhstan now has a formal legal architecture capable of supporting circular hazardous-fluid management — waste hierarchy requirements, waste-producer responsibility, licensed hazardous-waste recovery obligations, ownership-transfer rules, extended producer and importer responsibility, state waste cadastres, and digitalisation initiatives — yet implementation remains critically uneven. Public data confirm the immense scale of industrial waste accumulation, while government sources continue to identify weak project execution, low industrial-waste recycling rates, insufficient digital control, and an urgent need for modern technologies. The hazardous-fluid subset is particularly vulnerable because aggregate waste statistics do not consistently disaggregate waste oils, oil sludge, oily water, or refinery effluent streams. The paper argues that bridging the hazardous-fluid circular-economy gap requires a coordinated institutional roadmap — mandatory digital manifests for hazardous-fluid transfers, stream-specific EPR performance indicators for waste oils, stricter licensing and documentary proof for hazardous-waste recovery, third-party verification of treatment outputs, and multi-stakeholder research consortia in which independent environmental foundations coordinate stakeholder engagement while accredited laboratories, universities, public authorities, and industrial operators each contribute their specific technical and institutional mandates. These interventions would help mitigate regional soil, water, and air liabilities, reduce climate-related trade exposure under emerging carbon-border regimes, and accelerate technology localisation through university-backed scientific validation rather than purely commercial deployment. EEESEF, in its coordinating and monitoring capacity, contributes to this roadmap by facilitating stakeholder alignment and publishing independent, aggregated findings for public and regulatory use. [[1,2,3,4]]

Keywords: *Industrial Waste Policy; 2021 Ecological Code; Hazardous Fluids; Waste Mineral Oils; Oil Sludge; Refinery Effluents; Circular Economy; Kazakhstan; Extended Producer Responsibility; Independent Oversight; Technology Localisation; EEESEF.*

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Chapter 1: Introduction & The Transnational Regulatory Landscape

1.1 Global ESG and Climate Accounting Trajectories

The global industrial landscape is undergoing a structural transition in which environmental performance is no longer limited to voluntary corporate disclosure. Environmental, Social and Governance (ESG) criteria, lifecycle emissions accounting, product carbon-footprint verification, and supply-chain traceability are increasingly being converted into market-access conditions. For Kazakhstan, whose export profile is materially linked to energy-intensive resource extraction, metallurgy, chemicals, fuel logistics, and transport infrastructure, this transition fundamentally changes the strategic status of industrial waste management. **[5][6]**

Hazardous fluids are no longer only a domestic environmental-management problem; they are part of the evidence base through which industrial operators demonstrate control over lifecycle emissions, pollution leakage, material efficiency, and circular recovery. The European Union Carbon Border Adjustment Mechanism (CBAM) entered a transitional period from 2023 to 2025 and applies in its definitive regime from 2026; it covers selected carbon-intensive goods, including cement, iron and steel, aluminium, fertilisers, electricity, and hydrogen. While CBAM is formally directed at embedded greenhouse-gas emissions in covered goods and not directly at hazardous-waste fluids, it is relevant because it increases the importance of verified facility-level data, product-level environmental footprints, and credible management systems in export-oriented industrial corridors. **[5][6]**

Climate accounting also makes waste-fluid management more than a narrow pollution issue. Incinerating used oils as low-grade fuel may appear to solve a waste-disposal problem, but it destroys recoverable base oil, adds uncontrolled emissions burdens, and removes material from higher-value circular use. Dumping or poorly storing oily liquids creates remediation liabilities, contaminates land and groundwater, and undermines the credibility of environmental claims. Circularity therefore becomes a compliance infrastructure: it links waste classification, safe containment, digital tracking, licensed processing, verified recovery, and emissions accounting into one operational architecture. **[1][16]**

Kazakhstan can reduce climate-trade exposure by improving industrial data quality, closing uncontrolled waste-fluid pathways, and building verifiable domestic processing capacity. The core question this paper addresses is whether the 2021 Ecological Code is being translated from formal legal architecture into traceable recovery outcomes for fluids that are technically recoverable but environmentally hazardous. **[1][22]**

1.2 The Strategic Role of Independent Coordination

The argument for independent oversight is strongest when framed with institutional precision. Independent environmental foundations do not replace state regulators, nor do university laboratories substitute for licensed hazardous-waste operators. Their distinct value lies in occupying a credible coordinating layer between self-reported industrial data and state enforcement — a layer that is especially critical where baseline information is incomplete, treatment technologies are disputed, or operators have incentives to overstate recovery outcomes.

EEESEF — the Euro-Eurasia Environmental Science & Education Foundation — is well placed to fulfil this coordination function in Kazakhstan. As a UK-registered non-profit operating under a founding constitution that enshrines its apolitical and non-religious character under the laws of England and Wales, EEESEF carries a form of institutional neutrality that is difficult for commercial entities or government-affiliated bodies to replicate. This neutrality is not merely a reputational asset; it is what makes EEESEF's coordinating role trusted by all parties simultaneously — regulators, financiers, operators, and civil society. EEESEF's mandate is coordination and independent monitoring, not technical execution — a distinction that preserves its institutional neutrality and ensures its published findings remain credible and unconflicted. **[20][21]**

Within this architecture, each actor has a distinct and irreplaceable function. University laboratories validate waste-fluid composition, test recovered fractions, assess secondary-waste formation, and generate peer-reviewed datasets. Accredited laboratories verify pollutant concentrations, moisture levels, acid values, heavy metals, and residual hydrocarbon fractions. Independent foundations coordinate public-interest monitoring, convene stakeholders around shared protocols, facilitate the aggregation of findings, and channel international development or research cooperation. Together, these actors transform environmental oversight from an episodic inspection model into a continuous, transparent, and independently monitored system — precisely the architecture that Kazakhstan's industrial corridors currently lack. **[13][14]**

The strongest institutional model is a consortium rather than a single actor. A consortium allocates roles precisely: public authorities define legal requirements; industrial generators provide access and operational records; accredited laboratories and universities design sampling protocols, conduct analysis, and generate the scientific evidence base; independent foundations such as EEESEF coordinate stakeholder engagement, monitor process integrity, manage public reporting, and ensure no single commercial interest captures the oversight agenda; and technology providers submit their systems for performance validation through the consortium's laboratory partners. Such a design reduces commercial bias while creating the verified evidence base needed for financing, licensing, and technology localisation.

1.3 Scope of Inquiry & Boundary Protocols

This paper establishes a macro-level evaluation of hazardous waste-fluid processing across Kazakhstan's heavy industrial and manufacturing corridors. It maintains the thematic boundary of environmental and climate circular-economy compliance. Accordingly, the analysis prioritises statutory alignment, quantitative environmental baselines, hazardous-fluid lifecycle tracking, infrastructure bottlenecks, digital verification, technology validation, and export climate-risk implications. It does not evaluate unrelated corporate-governance metrics, labour policy, or general ESG branding claims except where they affect hazardous-fluid compliance.

The analysis focuses on three fluid categories. First, waste mineral oils and lubricants — including used engine oils, hydraulic oils, gear oils, turbine oils, locomotive lubricants, compressor oils, transformer oils relevant to industrial systems, and related fluids generated by heavy equipment.

Second, oil sludge and oil-contaminated liquids — including tank-bottom sludge, lagoon sludge, pipeline residues, oily water, and hydrocarbon-contaminated sediments or wash waters. Third, refinery effluents and process waters — including aqueous streams from refining, separation, washing, cooling, treatment, or industrial process operations where oil, metals, phenols, sulfides, suspended solids, or other contaminants create hazardous characteristics. **[1][3]**

The paper adopts a qualitative document-analysis method supported by a structured compliance matrix. Legal requirements are extracted from the 2021 Ecological Code and related EPR and waste-management instruments; observed practices are drawn from official waste information, government statements, and corporate disclosures. Compliance status is assessed using a four-point scale: Aligned, Partially Aligned, Not Aligned, and Insufficient Evidence. Where evidence is not strong enough to prove national compliance or non-compliance, the paper uses "Insufficient Evidence" or "Partial Alignment" rather than rhetorical certainty — a methodological choice that reflects the genuine opacity of Kazakhstan's current hazardous-fluid data architecture. **[1][2][8]**

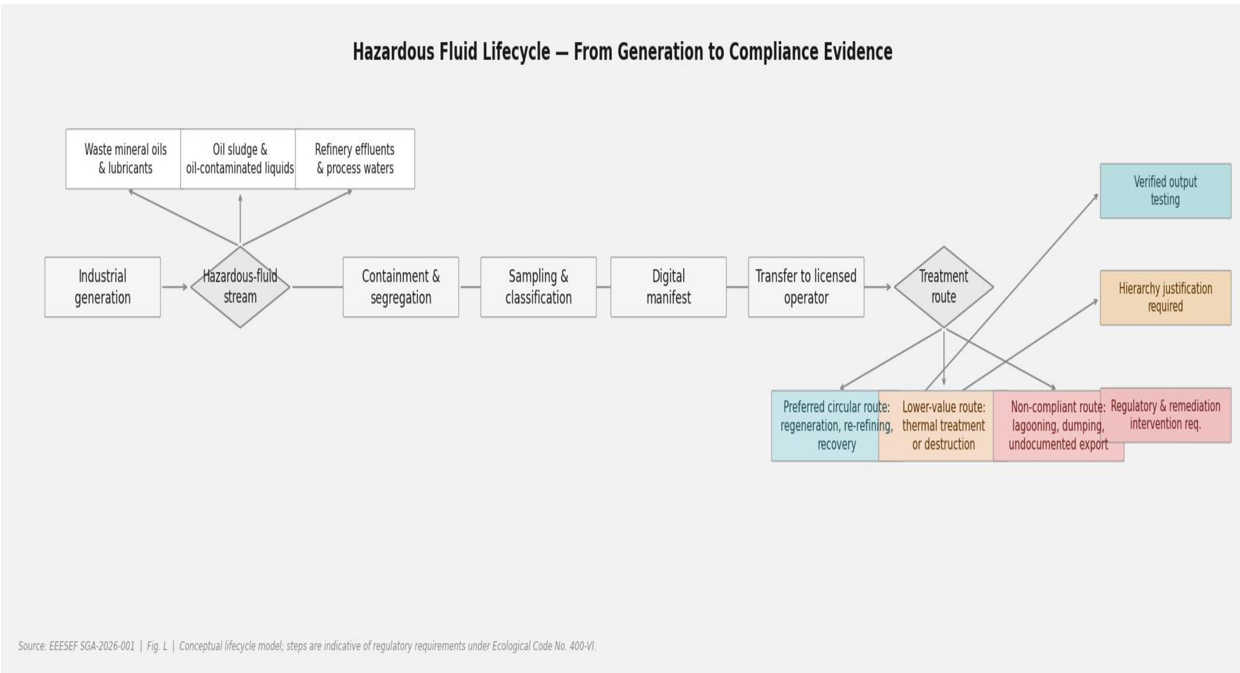

Figure L: Hazardous Fluid Lifecycle — From Industrial Generation to Circular-Economy Compliance Evidence

Chapter 2: Macro Regional Footprint & Waste Fluid Inventories

2.1 Cross-Sector Fluid Generation Metrics

Kazakhstan's hazardous-fluid challenge must be understood within the country's much larger industrial-waste footprint. National e-government information reports approximately 31.6 billion tonnes of accumulated industrial waste and about 1 billion tonnes generated annually, mainly technogenic mineral formations, overburden, ash, manufacturing waste, and other industrial residues. In March 2025, Kazakhstan's Prime Minister stated that enterprises store about 1 billion tonnes of industrial waste annually and that only about 11% of the total volume is recycled — instructing ministries to build clearer waste-management systems and digital solutions. **[3][4]**

These aggregate figures do not isolate hazardous fluids, but they provide the macro baseline: Kazakhstan has an industrial system large enough that even a small hazardous-fluid fraction represents a significant environmental and economic issue. Based on available sectoral data, the working planning estimate for hazardous waste mineral oil and related industrial fluids is approximately 120,000–180,000 tonnes per year. Because official statistics do not consistently disaggregate waste oils, oil sludge, and oily effluents in a publicly accessible, stream-specific format, that estimate should be treated as a scoping range rather than a final national statistic — and the absence of a more precise figure is itself evidence of the data gap this paper identifies. **[3][15][27]**

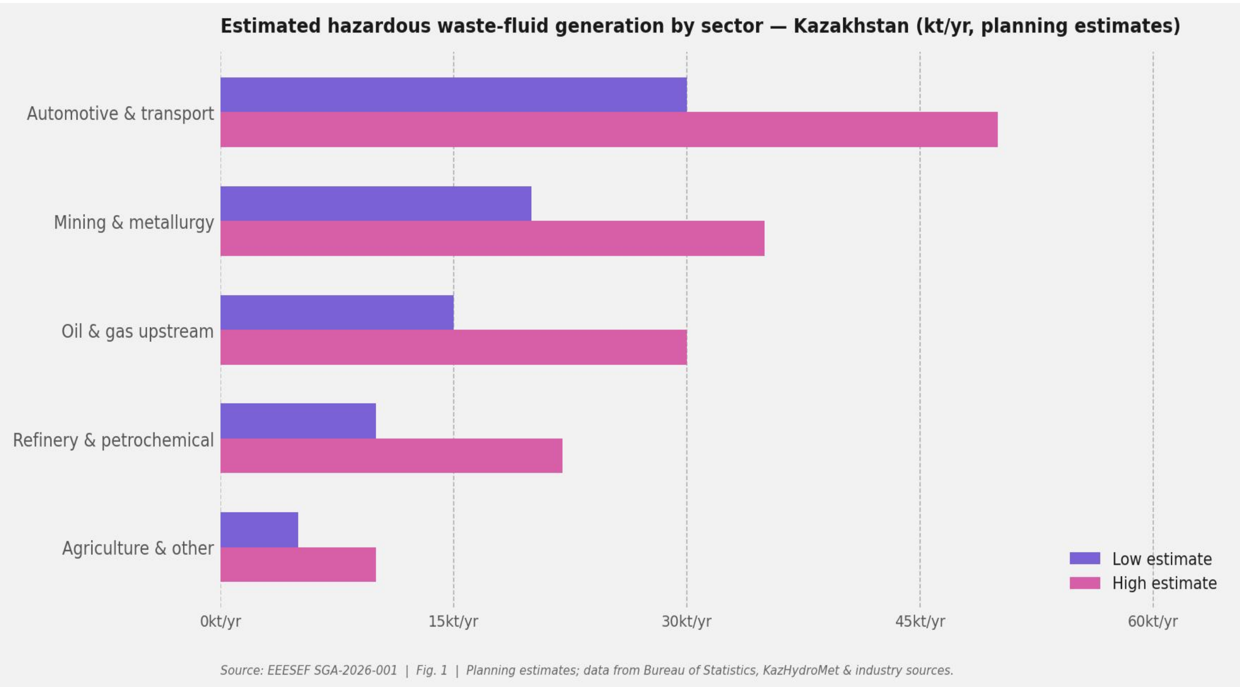

Figure 1: Estimated Hazardous Waste-Fluid Generation by Sector — Kazakhstan (planning estimates, thousand tonnes per year)

The mining and metallurgical sectors generate used lubricants, gear oils, hydraulic fluids, cutting fluids, and grease-contaminated process residues from extraction, crushing, smelting, rolling, and heavy transport. These sectors often operate in regions where industrial waste accumulation, tailings, and metallurgical residues already create high environmental pressure.

Waste-fluid management in such contexts cannot be separated from broader land, water, and air quality risks, because uncontrolled oils and oily waters can mobilise contaminants and complicate remediation. [7][13]

The upstream oil and gas sector generates drilling-related wastes, used engine oils, process fluids, oily sludge, tank residues, and oil-contaminated soils or sediments. KazMunayGas reports that in 2022 the KMG group had 1,132.3 thousand tonnes of waste in circulation, including 1,097.3 thousand tonnes classified as hazardous — demonstrating the scale of hazardous material handled by major operators alone. [7][15]

The transport and logistics grid generates locomotive lubricants, commercial fleet oils, hydraulic fluids, and engine oils from road and rail freight. Such streams are geographically dispersed, making digital manifests and collection systems particularly important. The automotive and commercial vehicle fleet supporting Kazakhstan's major oil export infrastructure — the Caspian Pipeline Consortium alone transports tens of millions of tonnes annually — represents a substantial recurring waste stream. [15][22]

Table 1: Quantitative Planning Baseline for Industrial Waste and Hazardous-Fluid Governance

Indicator	Figure / Status	Period	Source	Interpretive Use
Accumulated industrial waste	~31.6 billion tonnes	Publicly reported 2020s	eGov / national information [[3]]	Shows the legacy scale of industrial waste accumulation.
Annual industrial waste generation	~1 billion tonnes/yr	2020s; PM statement 2025	eGov; Prime Minister's Office [[3,4]]	Shows continuing pressure from resource-intensive industrial activity.
Industrial waste recycling rate	~11% (2025 PM); 29.7% recovered (2020 eGov)	2020 / 2025	eGov; PM Office [[3,4]]	Inconsistent definitions; need for stream-level tracking. Note: the 29.7% figure (2020 eGov) reflects recovered industrial waste under a broad definition; the 11% figure (2025 PM statement) applies a stricter recycling definition. The apparent decline reflects definitional narrowing, not necessarily a worsening recovery outcome.
KMG hazardous waste (single operator group)	1,097.3 kt classified hazardous in circulation (2022)	2022	KazMunayGas disclosure [[7]]	Illustrates hazardous-waste scale in one major operator group.

Hazardous waste mineral oil & related fluids	120,000–180,000 t/yr (working planning estimate)	SGA scoping estimate 2026	Sectoral analysis; requires official validation [[20]]	Used as policy-planning range, not an official national statistic.
Waste oil collection & regeneration rate	Not consistently publicly disaggregated	2021–2026	EPR and public waste-data review [[10,14]]	Core evidence of the hazardous-fluid data gap.

2.2 Legacy Disposal Models & Ecological Liabilities

The main circular-economy failure in hazardous-fluid management is the persistence of linear disposal pathways. Waste oils and oily liquids are often treated as low-value operational by-products even though many contain recoverable base oils or hydrocarbons. Legacy models include uncontrolled storage, lagooning, open or poorly engineered containment, land disposal, use as low-grade fuel, and export as crude feedstock for external processing. Each pathway removes value from the domestic circular economy and increases environmental uncertainty. **[1][9]**

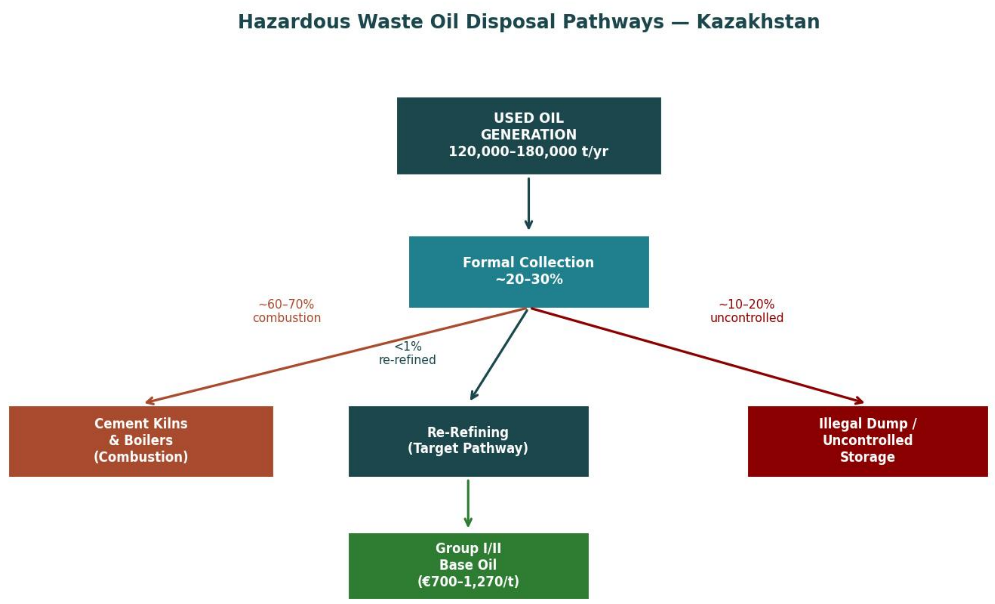

Figure 2: Hazardous Waste Oil Disposal Pathways — Kazakhstan (current state vs. target recovery pathway)

Incineration or use of waste oil as low-grade fuel can be legally permissible in some contexts if controlled, permitted, and emissions-compliant, but it is usually inferior to regeneration in the waste hierarchy when the fluid can be technically recovered. The core policy issue is not whether all thermal treatment is illegal; it is whether thermal destruction is being used as a default substitute for higher-value recovery. A circular-economy compliance regime should require operators to justify why regeneration, re-refining, or material recovery is infeasible before authorising lower-ranked options. **[1][16]**

Improper land and drainage disposal presents more direct ecological liability. Oily liquids can penetrate soil, spread through drainage networks, enter groundwater, or bind to sediments and remain persistent for years. Such contamination can create remediation obligations that exceed the avoided cost of proper treatment. If waste ownership, transfer, and treatment are not documented, liability can become diffuse: original generators, collectors, land users, transporters, and site operators may each deny responsibility. This is precisely why Articles 331, 336, and 339 of the Ecological Code must function as a chain rather than isolated provisions. [1][8]

Low-value transboundary export is a different kind of liability. If Kazakhstan exports collected waste fluids as crude unrefined material, it may reduce domestic storage pressure but loses the opportunity to build domestic recovery capacity, technical employment, and intellectual property. A circular industrial policy should therefore favour verified domestic regeneration and high-value processing where technically and economically viable, while treating export as a documented and auditable pathway rather than a default escape valve. [24][25]

2.3 Physical and Chemical Feedstock Characteristics — The Case for Advanced Recovery

Industrial hazardous fluids are not uniform liquids, and understanding their variability is the starting point for designing effective recovery systems. Used oils and sludge streams vary by original formulation, machinery type, operating temperature, age, contamination exposure, and collection practice. Typical contaminants include water, suspended solids, metal wear particles, soot, oxidised hydrocarbons, degraded additives, sulfur compounds, acidic compounds, solvents, phenols, and emulsified hydrocarbons. The same nominal stream — such as "used hydraulic oil" — can range from a highly regenerable resource to a heavily contaminated hazardous mixture depending on field conditions. [17][18]

This variability makes the case for advanced physical processing especially compelling. Three principal technology families are applicable to Kazakhstan's hazardous fluid streams, each suited to a different feedstock profile and recovery objective.

Acid-clay re-refining is the most widely deployed technology globally. It uses sulphuric acid to precipitate contaminants followed by activated clay filtration to restore base oil colour and stability. It achieves recovery yields of around 60–70% and produces a usable base oil product. Its limitations are significant: it generates acid sludge, spent clay, and chemical effluents that require separate hazardous-waste management, creating secondary environmental obligations. Operating costs are moderate but environmental compliance costs are substantial. As a result, acid-clay processes are being phased out or heavily regulated in the European Union and are no longer considered best available technology for new investment. [17][18]

Solvent extraction re-refining uses propane, furfural, or N-methyl-2-pyrrolidone (NMP) to selectively dissolve base oil fractions and separate them from contaminants. Recovery yields improve to approximately 70–80% and the process avoids acid sludge.

However, solvent recovery systems require significant capital investment, energy consumption is higher, and the handling of solvents introduces its own safety and environmental management requirements. The technology is technically sound but operationally complex, making it better suited to large, established industrial settings with experienced maintenance workforces. [17][18][19]

High-vacuum thin-film distillation represents the current state of the art for hazardous waste oil recovery. Inclined wall wiped film evaporators — the most advanced variant of this family — separate base oil from contaminants entirely through controlled thermal evaporation under deep vacuum, without any chemical reagents. The process achieves base oil recovery yields of 84–90%, generates no acid sludge, no spent clay, and no chemical effluents. The non-condensable gas fraction is self-consumed as furnace fuel, creating a closed energy loop. Secondary water fractions are recoverable as clean process water. This performance profile has been independently validated in peer-reviewed literature and demonstrated in commercial facilities in China, Germany, and the United States processing facilities collectively processing several hundred thousand tonnes annually. The absence of chemical inputs, combined with the highest recovery yields of the three technology families, makes high-vacuum thin-film distillation the strongest candidate for greenfield investment, subject to feedstock-specific validation. **[17][18][19]**

The policy implication is clear and constructive: Kazakhstan's diverse hazardous fluid streams — from automotive lubricants to mining hydraulic oils to refinery process fluids — contain substantial recoverable value. Advanced physical processing does not merely dispose of these materials more safely; it converts a compliance obligation into a domestic resource and a platform for industrial capability. For policymakers, this reframes the investment case: advanced recovery infrastructure is not a regulatory cost — it is a productive industrial asset that generates verified outputs, supports domestic employment, and strengthens environmental credibility with export markets. The economic performance of high-vacuum distillation facilities at commercial scale is well-documented in international literature and operational references; detailed financial modelling for a Kazakhstan-scale facility is set out in EEESEF Technical Report TR-001. [20]

Kazakhstan's industrial corridors are well-suited to this technology. The country already has an established engineering and industrial maintenance workforce, existing refinery infrastructure at Atyrau, Pavlodar, and Shymkent, and a regulatory framework that explicitly prioritises material recovery above energy recovery in its waste hierarchy. The technology is ready, the feedstock is abundant, the economics are compelling, and the legal foundation is in place. What is currently missing is the institutional architecture to connect all three — and that is the gap that this paper, and EEESEF's role within the proposed consortium, directly addresses. [1][20]

2.4 Regional Compliance Risk Typology

A regional compliance-risk typology helps translate national policy into practical intervention priorities, recognising that Kazakhstan's industrial geography creates distinct hazardous-fluid challenges across different corridors.

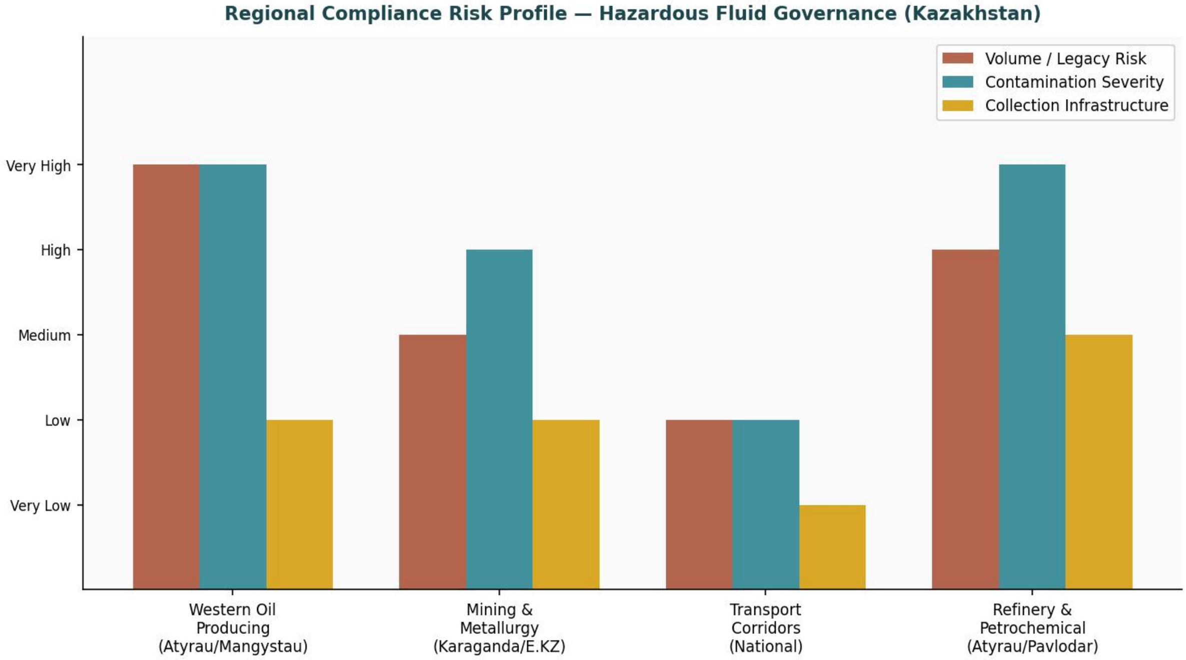

Figure 3: Regional Compliance Risk Profile by Corridor — Hazardous Fluid Governance (Kazakhstan)

Western oil-producing regions — Atyrau and Mangystau oblasts — face the highest concentration of oil sludge, oil-contaminated lands, tank-bottom residues, produced-water-adjacent oily streams, and refinery or pipeline waste fluids. In these corridors, the dominant risks are historical pollution, lagoon storage, incomplete sludge removal, and uncertain final treatment outcomes. The priority intervention is a verified inventory of oil-contaminated sites and fluid/sludge volumes, followed by licensed treatment capacity and independently tested remediation outputs. [7][13]

Mining and metallurgical regions — Karaganda, East Kazakhstan, and the Balkhash copper corridor — face a different profile. Waste fluids are linked to heavy equipment, hydraulic systems, rolling mills, smelting machinery, and industrial maintenance operations. Used oils in these regions may contain elevated metal particles, process residues, coolants, and high mechanical impurity loads. Source segregation and maintenance-shop collection protocols are the critical first intervention to ensure that fluids remain recoverable rather than becoming mixed hazardous sludge. [4][13]

Transport corridors — national rail networks, commercial road freight, and the Caspian Pipeline Consortium logistics chain — create a third profile. Locomotive depots, freight fleets, and service hubs generate recurring streams of engine oil, gear oil, brake fluids, coolants, and hydraulic fluids. The challenge is collection-network design rather than treatment technology.

A circular system must make legal collection easier than informal disposal through registered collection points, standard containers, transport manifests, contracts with licensed operators, and EPR-linked financing that rewards recovered volumes. [10][14]

Refinery and petrochemical nodes at Atyrau, Pavlodar, and Shymkent create a fourth profile. The relevant streams include aqueous effluents, oily water, tank residues, process sludges, chemical cleaning residues, and treatment-plant by-products. These facilities typically have more sophisticated internal environmental systems than dispersed smaller generators, but their environmental risk is higher because pollutant loads can be concentrated. The appropriate compliance test is performance-based: pollutant concentrations in treated water, sludge-management routes, recovery of hydrocarbon fractions, and residue disposal must be verified rather than assumed from the existence of internal procedures. [7][8]

2.5 Critical Data Gaps — What Kazakhstan Cannot Yet Measure

KEY DATA GAPS: Six Measurements Kazakhstan Currently Lacks

- Stream-specific waste oil volumes — total tonnes generated per sector, per region, per year, disaggregated from aggregate industrial waste statistics.
- Collection rates by stream type — what percentage of generated waste oils, sludge, and oily effluents enters formal licensed pathways versus informal combustion, dumping, or export.
- Treatment output quality — whether recovered base oil, treated water, or processed sludge meets applicable product or discharge standards, verified by accredited testing.
- EPR stream-specific outcomes — tonnes collected, regenerated, thermally treated, exported, and rejected per product category, per operator, per year.
- Secondary waste quantities — the volumes, classifications, and final disposal routes of residues generated by treatment processes.
- Emissions and lifecycle data — greenhouse gas emissions and removals associated with waste-fluid management at facility and product level, linkable to ISO 14064-1 and ISO 14067 frameworks.

Without these six data dimensions, national compliance cannot be verified, EPR performance cannot be assessed, technology investment cannot be risk-managed, and Kazakhstan's industrial export sectors cannot credibly respond to international climate-accounting requirements. The absence of this data is not merely a bureaucratic inconvenience — it is the single largest obstacle to building the circular hazardous-fluid infrastructure that the 2021 Ecological Code mandates. [3][4][11][12]

Chapter 3: The 2021 Ecological Code Compliance Matrix

3.1 Statutory Mandates of the 2021 Ecological Code

The 2021 Ecological Code — formally the Code of the Republic of Kazakhstan dated 2 January 2021, No. 400-VI — is the primary legal foundation for hazardous-fluid compliance. For precision, this paper treats No. 400-VI as the governing instrument and relies on the WECOOP unofficial English translation and the Adilet legal information system for textual references, avoiding reliance on the superseded 2007 Environmental Code. **[1][2]**

The waste hierarchy is established in Article 329. The Code requires waste-prevention and recovery logic before final removal, and it requires technical capability, economic feasibility, precaution, sustainable development, and environmental-health impacts to be considered when applying the hierarchy. For hazardous fluids, Article 329 creates the benchmark that recoverable oils and oily materials should not default to disposal when regeneration or recovery is feasible. This provision is directly aligned with the European Union's Waste Framework Directive approach and signals Kazakhstan's intention to mirror international best practice. **[1][26]**

Waste-producer responsibility is addressed in Article 331, which provides that legal entities that are waste producers are responsible for proper management from generation until transfer under the ownership of an entity engaged in waste recovery and removal. Article 339 then governs waste ownership and waste-management responsibility, stating that waste producers are owners of waste generated by them and that current and former waste owners are responsible for meeting environmental waste-management requirements until transfer to a licensed recovery/removal operator. **[1][8]**

Article 336 is narrower and more operational: it requires business entities engaged in processing, neutralisation, recycling, or destruction of hazardous waste to obtain an environmental-protection license for the relevant hazardous-waste activity. The license must specify the type and amount of hazardous waste, the activity, technical site requirements, and the method applied. For hazardous fluids, Article 336 is the licensing gateway that determines which operators may lawfully recover or remove specific hazardous waste types. **[1][8]**

EPR is addressed through Article 332 and Chapter 31, including Article 386 and related provisions. Article 386 requires producers and importers of products on the EPR list to ensure collection, transportation, processing, sorting, treatment, neutralisation, and/or recycling of waste generated after those products lose consumer properties, either through their own system or by contract with the EPR operator and payment of recycling fees. Because oils are among the product categories treated in EPR discussions and exemptions, EPR is directly relevant to waste-oil collection and regeneration. **[1][10]**

Table 2: Legal Provisions Translated into Hazardous-Fluid Compliance Benchmarks

Code / Policy Element	Legal Function	Hazardous-Fluid Compliance Benchmark	Primary Gap Tested
Art. 329: Waste Hierarchy	Prioritises prevention, reuse, recycling and recovery before removal.	Recoverable waste oils and oily materials must not default to disposal or low-grade burning.	Infrastructure / hierarchy implementation
Art. 331: Waste-Producer Responsibility	Waste producers remain responsible for proper management until lawful transfer.	Generators must document the route from generation to recovery/removal.	Governance / chain of custody
Art. 336: Licensing of Hazardous-Waste Recovery/Removal	Requires licensed operators for processing, neutralisation, recycling and destruction of hazardous waste.	Hazardous fluids must be treated only by operators licensed for relevant waste type, amount, method and site.	Licensing / treatment capacity
Art. 339: Waste Ownership & Transfer	Clarifies ownership, responsibility, and transfer to licensed operators.	Transfer documents must prove lawful movement and responsibility allocation.	Data / legal accountability
Arts. 332, 386–392: EPR	Requires collection, transport, treatment and/or recycling for listed products through own systems or operator contracts.	Waste oils need stream-specific collection, regeneration and reporting indicators.	EPR performance / financing
State Cadastre, Registers, Digital Systems	Places waste information in state systems and supports reporting.	Hazardous-fluid quantities and treatment outcomes should be digitally traceable.	Data quality / transparency

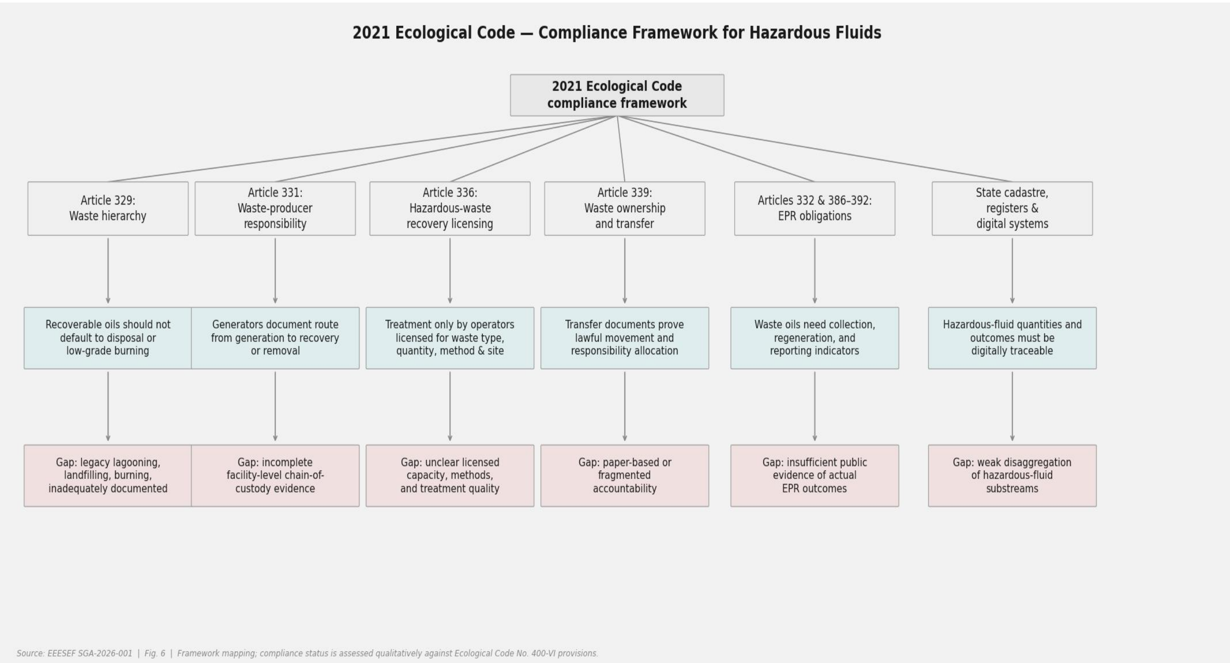

Figure 6: 2021 Ecological Code — Compliance Framework for Hazardous Fluids (Articles, Benchmarks, and Gaps)

3.2 Extended Producer Responsibility (EPR) Realities

The EPR framework is one of the most important mechanisms for waste-oil circularity because it can convert general legal duties into financed collection and treatment systems. In principle, EPR shifts part of the organisational and financial burden from public authorities to producers and importers whose products become waste. For hazardous fluids, the mechanism is attractive because individual generators may lack incentives to organise high-quality collection, while a producer/importer system can aggregate flows and finance processors. **[10][14]**

The practical problem is transparency of outcomes. EPR obligations may be formally present, but the policy question is whether waste oils are actually collected, regenerated, treated, or otherwise routed to licensed facilities at measurable rates. Producers and importers can fulfil EPR either through their own collection/recycling systems or by contracting with an EPR operator and paying recycling fees. However, the publicly accessible evidence does not consistently provide stream-specific indicators for waste oil collection, regeneration, rejected feedstock, export, or final treatment. Fee payment satisfies one formal requirement, but the circular-economy objective is achieved only if collected fluids are actually recovered or treated in a verified way. **[10][14]**

Where partial data are available, they reveal a significant structural gap. Kazakhstan's government e-portal records show that under the EPR framework, waste oils collected and recycled amounted to approximately 4,200 tonnes in 2017, rising to 11,252 tonnes in 2018 and 15,686 tonnes in the first nine months of 2019 — a positive trend, but far below the planning estimate of 120,000–180,000 tonnes per year in total hazardous-fluid generation. A 2025 SWITCH-Asia baseline assessment identified registered oil-recycling capacity in Kazakhstan of approximately 44,000 tonnes per year. The gap between stated capacity and estimated generation, and between collected volumes and reported capacity, points directly to the structural weaknesses this paper identifies: fragmented data, insufficient collection networks, and the absence of stream-specific EPR outcome reporting. **[10][14]**

For waste oils, meaningful EPR metrics would include: registered producers/importers; market volume of oils placed on the market; waste oil collected; percentage regenerated; percentage thermally treated; percentage exported; treatment residues; and verified compliance by processor type. The paper therefore rates EPR for waste-oil outcomes as "Insufficient Evidence." The legal mechanism exists, but public data are too fragmented to demonstrate whether the system is achieving hazardous-fluid circularity at scale. The policy remedy is to require annual stream-specific EPR reporting and to mandate that EPR operators publish disaggregated waste-oil data by treatment route. **[1][10][14]**

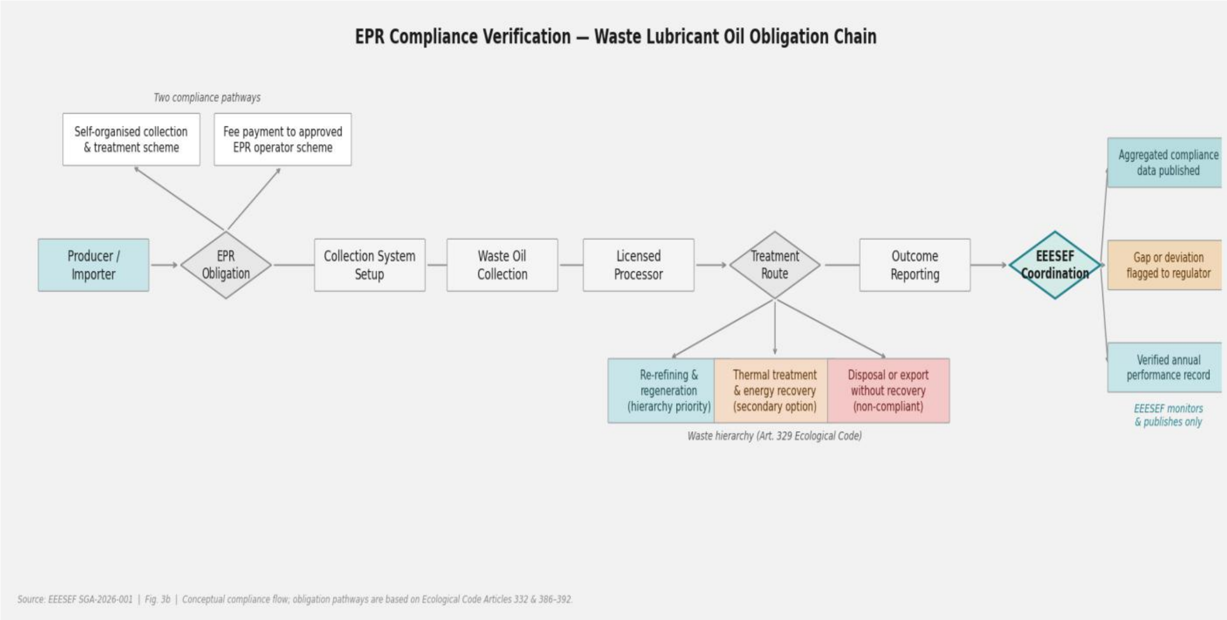

Figure 3b: EPR Compliance Verification Flow — Waste Lubricant Oil Obligation Chain (Kazakhstan, Art. 332 & 386–392 Ecological Code)

3.3 National All-Waste Management Concept Integration

In March 2025, the Prime Minister instructed ministries to develop a concept for the management of all types of waste, aimed at centralising waste-management processes, involving stakeholders, and building a cyclical economy model. The same communication noted that only a small number of preferentially financed waste-management projects had been financed, and that industrial-waste recycling remained low. Ministries were also instructed to develop digital solutions for management, monitoring, and control of municipal and industrial waste. [4]

For the hazardous-fluid agenda, the significance of this all-waste concept is institutional rather than merely rhetorical. A national concept can solve problems that individual facility permits cannot solve alone: standardised waste categories, digital transfer protocols, financing pipelines, regional processor networks, public-private responsibilities, and measurable recovery targets. Hazardous fluids should be explicitly included in such a concept rather than left inside broad "industrial waste" categories. [3][4]

The concept should avoid mandating a single technology. Instead, it should establish performance standards: licensed capacity, pollutant thresholds, recovery ratios, secondary-residue control, digital manifest completion, third-party verification, and public reporting. This allows physical distillation, filtration, dehydration, thermal treatment, biological remediation, chemical neutralisation, or combined systems to compete on verified performance rather than promotional claims. A national all-waste concept also provides the policy bridge between environmental compliance and industrial localisation. Kazakhstan can use hazardous-fluid management to build domestic environmental technology, laboratory capacity, applied engineering curricula, and recovery markets. [1][14][20]

3.4 Core Compliance Matrix

Table 3: 2021 Ecological Code Compliance Matrix — Hazardous-Fluid Circular-Economy Gaps

Legal / Policy Requirement	Observed Hazardous-Fluid Practice	Evidence Basis	Compliance Status	Dominant Gap	Intervention Direction
Waste Hierarchy (Art. 329)	Legacy lagooning, landfilling, low-grade burning, or insufficiently documented treatment persists for oil sludge and some waste-oil pathways.	Code hierarchy; government concern over low recycling; corporate oil-pollution disclosures. [[1,4,7]]	**Partially Aligned nationally; Not Aligned where sludge lagoons persist.**	Infrastructure / hierarchy implementation	Require hierarchy justification before disposal or thermal destruction; prioritise regeneration.
Waste-Producer Responsibility (Art. 331)	Large generators may have internal systems, but public information does not prove complete generation-to-treatment traceability for hazardous fluids.	Producer responsibility under Code; corporate disclosures; data-gap evidence. [[1,7]]	**Partially Aligned**	Governance / documentation	Require facility-level hazardous-fluid balances and annual chain-of-custody attestations.
Licensing of Hazardous-Waste Recovery (Art. 336)	Licensing framework exists; uncertainty remains over capacity, methods, waste types, and treatment quality for hazardous fluids.	Code licensing requirements; legal summaries on industrial waste. [[1,8]]	**Partially Aligned**	Licensing / capacity	Publish licensed operator capacities by hazardous-fluid category and method; audit actual treatment outputs.
Waste Ownership & Transfer (Art. 339)	Responsibility continues until transfer to licensed recovery/removal operator, but paper-based or fragmented records can obscure accountability.	Code Art. 339; QazaqGreen summary of ownership and transfer rules. [[1,9]]	**Partially Aligned**	Chain of custody	Mandate digital manifests linked to permits, operator licenses, and receiving-facility confirmations.

EPR for Oils & Oil Products (Arts. 332, 386–392)	EPR mechanism exists, but public waste-oil outcome data are not sufficiently disaggregated.	Code EPR provisions; EPR practice summaries. [[1,10]]	**Insufficient Evidence on actual outcomes**	EPR data / finance	Set waste-oil collection and regeneration sub-targets; publish annual stream-specific EPR performance.
State Cadastre, Reporting & Digital Platforms	Industrial-waste data exist, but hazardous-fluid substreams are weakly disaggregated; digital management is still being expanded.	eGov industrial-waste data; PM instruction on digital systems. [[3,4]]	**Partially Aligned**	Data / systems	Revise statistical categories; integrate hazardous fluids into digital tracking and treatment-output reporting.
Climate & Export-Risk Alignment	Industrial operators face increasing demand for verified emissions and lifecycle data; waste-fluid data are not yet integrated into product-level carbon evidence.	CBAM regime and embedded-emissions reporting; ISO carbon-accounting standards. [[5,6,11,12]]	**Partially Aligned / Emerging**	Climate accounting	Link hazardous-fluid management data to ISO 14064-1 organisational inventories and ISO 14067 product carbon footprints.

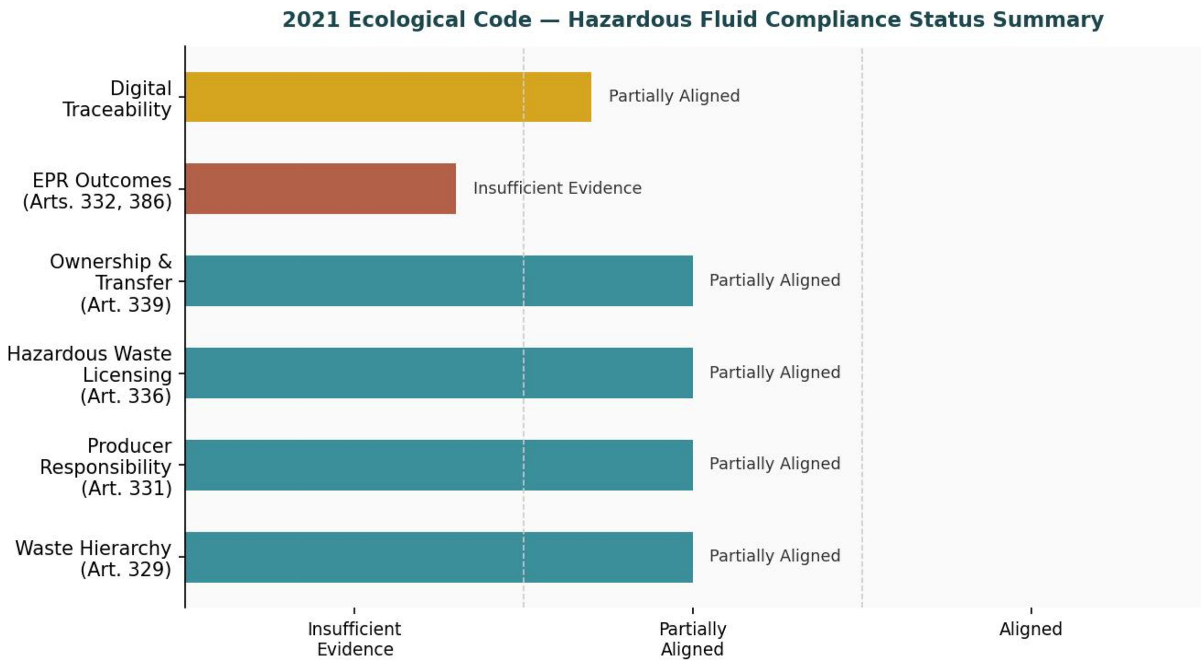

Figure 4: Summary of 2021 Ecological Code Compliance Status by Provision — Hazardous Fluid Streams

3.5 Ratings Rationale and Legal Caveats

The compliance ratings used in the matrix should be read as policy-diagnostic ratings, not as determinations of legal liability against any particular facility. "Partially Aligned" means that the legal instrument exists and some implementation evidence is present, but the public evidence does not show complete, verified, stream-specific compliance. "Not Aligned" is used only where a practice — such as legacy sludge lagooning or uncontrolled storage — is inconsistent with the hierarchy and safe-management logic of the Code. "Insufficient Evidence" is used where the formal mechanism exists but public outcome data are too weak to assess performance. **[1][2]**

The Article 336 and Article 339 distinction is essential and should not be collapsed. Article 336 concerns licensing of hazardous-waste processing, neutralisation, recycling, and destruction activities. Article 339 concerns waste ownership and responsibility until transfer to a licensed recovery/removal operator. A defensible compliance matrix must treat licensing, ownership, and transfer as connected but separate legal functions.

The matrix does not claim that Kazakhstan lacks modern operators or that all facilities use legacy practices. Some large industrial groups may have internal systems, contracted processors, and environmental disclosures that exceed minimum requirements. The problem is system-level verification: a national circular-economy compliance framework needs evidence that is comparable across operators, regions, and streams. Isolated good practices do not substitute for a transparent national data architecture. **[9][13]**

Chapter 4: Systemic Institutional Bottlenecks & Gaps

4.1 The Enterprise Information and Baseline Data Gap

The first systemic bottleneck is the absence of reliable stream-level baseline data. Kazakhstan has public aggregate data on industrial waste and some corporate disclosures on hazardous waste, but hazardous fluids are not consistently visible as distinct streams. This creates a measurement gap before the compliance analysis even begins. If waste oils, oil sludge, oily water, and refinery effluents are reported under broad categories, regulators and policymakers cannot determine whether circular recovery is improving or whether hazardous fluids are merely shifting between storage, incineration, export, and disposal. [3][4]

At enterprise level, the data problem becomes more acute. Many facilities can identify waste generation for permit or internal accounting purposes, but fewer can produce independently verified lifecycle data connecting generation, containment, sampling, classification, transport, treatment, recovered products, emissions, residues, and final disposal. Without this chain, an enterprise cannot prove compliance in a way that satisfies regulators, financiers, insurers, export customers, or carbon-accounting auditors. [11][12]

ISO 14064-1 addresses organisational-level quantification and reporting of greenhouse-gas emissions and removals; ISO 14067 addresses product carbon-footprint quantification. These standards do not themselves create Kazakhstan waste-law duties, but they provide a methodological structure for climate-risk evidence. When hazardous-fluid systems are poorly tracked, facilities may fail to account for emissions from waste burning, transport, recovery processes, purchased services, or product-level material efficiency — creating unquantified liability in an era of tightening cross-border carbon accounting. [11][12]

The baseline data gap also directly affects technology deployment. A processor cannot design a reliable recovery system without knowing feedstock variability; a financing institution cannot model project performance without knowing waste supply; and a regulator cannot compare technologies without verified inputs and outputs. The first intervention is therefore not a treatment plant — it is a baseline architecture: standardised categories, sampling protocols, digital manifests, and an independent coordination layer that aggregates, monitors, and publishes verified data across the system. [20][21]

4.2 Administrative and Verification Roadblocks

Kazakhstan's Ecological Code and permitting architecture create a formal pathway for environmental assessment, waste-management programmes, licensing, and facility compliance. However, new treatment facilities often require environmental impact assessment (OVOS), technical documentation, licensing, operator approval, land-use coordination, and financing review. In practice, the time between a proposed circular technology and a verified operating facility can be long enough that legacy storage and informal practices continue unabated. [8][24]

The problem is not that environmental review is unnecessary — it is that review procedures must be technically competent, predictable, and proportionate. Hazardous-fluid plants need robust assessment because they can create serious secondary risks. But if assessment rules are unclear or review capacity is weak, even environmentally beneficial projects may stall.

A better permitting model would combine strict environmental safeguards with a faster pathway for demonstrably beneficial circular infrastructure: pre-approved technical guidance for hazardous-fluid processing categories, clear documentation templates, performance-based emission and residue standards, and a regulatory helpdesk for projects using best available techniques. **[8][24]**

Verification roadblocks also arise after facilities are approved. A plant may be licensed, but the system still needs proof that it processes the claimed waste types, meets permitted quantities, produces recovered outputs that meet specifications, and manages residues safely. This requires inspections, sampling, audit trails, and public reporting. Where regulators lack laboratory or staff capacity, independent foundation and university consortium involvement becomes essential rather than merely useful. **[13][14]**

4.3 Financing, Market and Technology-Validation Gaps

Advanced hazardous-fluid processing requires significant capital expenditure, stable feedstock supply, skilled operators, reliable energy, emissions controls, laboratories, and markets for recovered products. Public financing mechanisms exist but have not always moved quickly — the 2025 government meeting noted that a preferential financing mechanism had approved 94 waste-management projects, but only six had been financed at that point. This indicates a project-development bottleneck: concept notes may exist, but bankable, technically validated, and permit-ready projects remain limited. **[4][24]**

Technology providers often present recovery figures such as high percentages of reclaimed base oil or near-zero liquid effluent. These claims may be plausible for specific feedstocks and operating conditions, but policy should require verification before financing or scaling. A credible technology-validation protocol would compare feedstock input, recovered oil quality, water quality, air emissions, solid residues, energy consumption, maintenance requirements, and economic performance over time, including failure modes such as off-spec feedstock, high water loads, and residue management challenges. **[17][18]**

The financing gap can be addressed by tying public incentives to verified outcomes. Concessional loans, tax incentives, grants, or green-fund support should be conditional on digital feedstock tracking, licensed operations, third-party testing, transparent residue management, and annual performance reporting. This prevents public support from becoming a subsidy for unproven technology while still accelerating localisation of genuinely beneficial processing capacity. Within this conditional framework, independent coordination bodies play a vital role: monitoring adherence to reporting protocols, facilitating transparent communication between operators and regulators, and publishing aggregated compliance indicators that no single party could credibly produce alone. **[14][20][21]**

4.4 Institutional Fragmentation and Accountability

Hazardous-fluid management crosses several institutional boundaries: environmental regulation, industrial policy, energy policy, transport, local government, statistics, digitalisation, customs, EPR finance, and research policy. Fragmentation creates gaps because no single institution can solve the whole lifecycle. A ministry may set rules; a local authority may handle land and permitting; an operator may collect fees; an industrial company may generate waste; a processor may treat it; a statistics body may aggregate data; and a university may hold technical expertise. Without a shared data architecture, each actor sees only part of the chain — and accountability evaporates at the interfaces. **[3][4][13]**

Accountability depends on public transparency. The Code contains transparency provisions for the EPR operator, including annual reporting duties. The policy question is whether those reports provide stream-specific information in a format useful for hazardous-fluid oversight. An annual report stating aggregate fees or broad waste categories is insufficient; the system needs data by product category, waste stream, treatment method, recovery output, region, and licensed facility. **[1][10]**

The proposed institutional model is a layered one: state authority for legal obligations; operator responsibility for compliance and financing; licensed processors for lawful treatment; digital platforms for traceability; accredited laboratories for measurement; independent foundations for public-interest oversight; and universities for research, validation, and localisation. Each layer has a distinct role, and the value lies in the interaction between them — which is why the consortium model, rather than single-actor intervention, is the appropriate design for Kazakhstan's hazardous-fluid governance challenge.

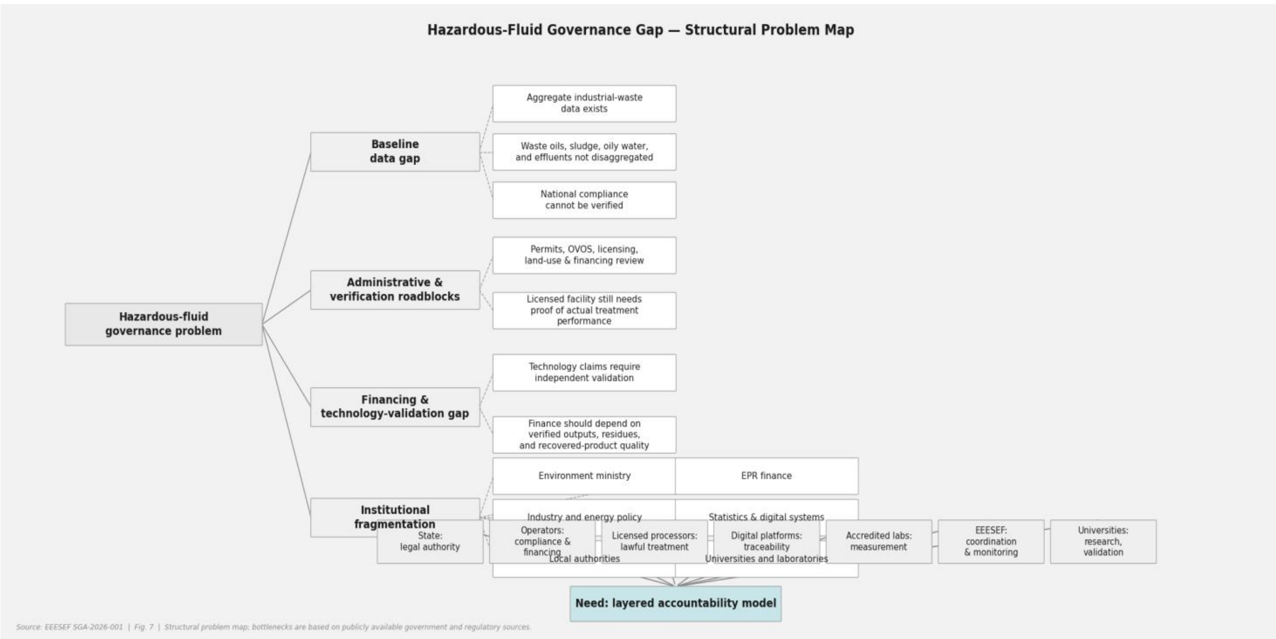

Figure 7: Hazardous-Fluid Governance Gap — Structural Problem Map and Layered Accountability Model

4.5 The EEESEF Coordination & Monitoring Model

An effective independent coordination function must operate through precisely defined mandates. It does not issue permits, impose penalties, conduct laboratory analyses, or substitute for the Ministry of Ecology, accredited testing laboratories, or university research programmes. Its value is different, and arguably more durable: it occupies the coordinating space between actors who have complementary roles but no natural mechanism for neutral alignment. Regulators, operators, university researchers, laboratory analysts, and technology providers all have their own institutional incentives; an independent foundation with no commercial interest in any outcome can hold these actors in a common framework and ensure that the overall system remains publicly accountable. **[20][21]**

EEESEF's role in Kazakhstan is structured around coordination, monitoring, and facilitated reporting — not around technical execution. Concretely, this means: initiating and managing memoranda of understanding (MoUs) between selected universities, accredited laboratories, and participating industrial operators; defining shared data templates and chain-of-custody protocols that each technical partner then implements; monitoring that agreed protocols are followed during each phase; and aggregating results into public-interest findings that no single technical partner could credibly publish without the risk of perceived bias. Each pilot corridor operates under a defined sampling plan and a public reporting format for aggregated findings, with commercially sensitive data protected under confidentiality provisions within the MoU. The Foundation's apolitical and non-religious status — enshrined in its UK constitution as a core founding principle — is what makes this coordination trusted by all parties simultaneously. **[20][21]**

The Foundation does not seek equity participation in industrial facilities, does not receive fees from operators whose facilities it monitors, and does not accept revenue from technology vendors whose systems are evaluated by consortium laboratory partners. This financial independence is not a peripheral feature — it is a founding constitutional principle. The practical consequence is significant: an independent coordination body that is structurally insulated from commercial capture is rare in any industrial ecosystem, and this is precisely what makes EEESEF’s facilitated findings credible and useful to government as an input for regulatory decision-making.

In practical governance terms, EEESEF's coordination model converts a fragmented multi-actor landscape into a structured, transparent, and publicly accountable system. Independent foundations convene; accredited laboratories and university partners conduct the technical work; findings are aggregated and published under EEESEF's coordination; and technology localisation becomes tied to measured, independently monitored environmental performance rather than self-reported commercial promotion. For advanced technologies such as vacuum wiped film distillation — documented in detail in EEESEF's companion Technical Report TR-001 — it is precisely this coordinated, multi-actor validation pathway, managed by an unconflicted coordinating body and executed by university and laboratory partners, that converts a commercially promising technology into a bankable, licensable, and nationally scalable deployment pathway. **[20][21]**

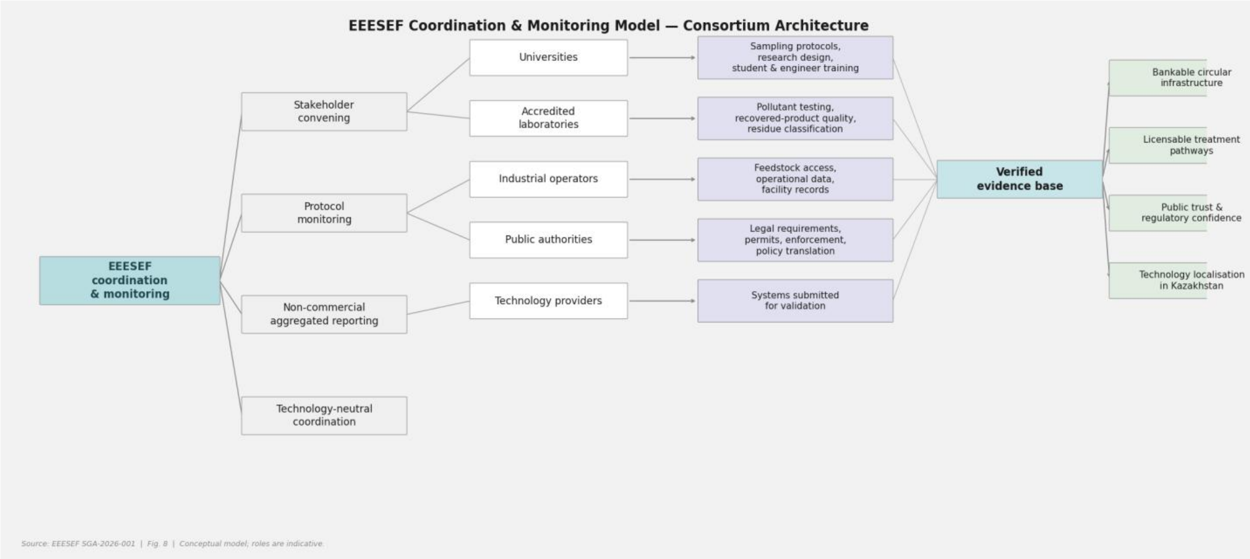

Figure 8: EEESEF Coordination & Monitoring Model — Consortium Architecture and Independent Reporting Framework

Chapter 5: Strategic Interventions & Conclusions

5.1 Advanced Physical Processing Paradigms

To bridge the hazardous-fluid circular-economy gap, Kazakhstan should prioritise advanced processing pathways that maximise material recovery while minimising secondary pollution. The case for high-vacuum physical processing is strong precisely because it aligns with Kazakhstan's existing industrial strengths: the country has refinery engineering expertise, a chemical and mechanical maintenance workforce, and existing infrastructure that can be adapted or co-located with waste oil recovery operations. **[20][22][28]**

A national processing paradigm should include four operational tiers. Tier one is prevention and segregation: avoiding contamination, separating waste oils from water and solvents, and preventing mixing that destroys regeneration potential. Tier two is collection and pre-treatment: leak-proof containment, sampling, dehydration, filtration, and classification. Tier three is recovery: regeneration, distillation, re-refining, oil-water separation, or other licensed processes matched to feedstock. Tier four is final treatment and residue management: destruction, neutralisation, stabilisation, or disposal only for fractions that cannot be safely recovered. **[17][18][19]**

For a detailed technical assessment of vacuum distillation technology — including the inclined wall wiped film evaporator process, its performance credentials, verified yield data of 84–90% base oil recovery without chemical inputs, and the reference 30,000 tonne per year facility design developed for Almaty — readers are referred to EEESEF Technical Report TR-001 (June 2026). That report provides the primary technology evidence base that underpins the processing paradigm recommendations in this SGA. **[20]**

Not every hazardous fluid can become high-grade base oil, and not every sludge can be converted into clean water and reusable hydrocarbons. But every stream can be classified, tracked, treated by authorised operators, and reported. The immediate compliance objective is not perfection; it is eliminating unverified pathways and replacing them with documented, licensed, and independently tested treatment routes. Where high-value recovery is technically feasible — and the evidence strongly suggests it is for the majority of Kazakhstan's waste mineral oil stream — it should be prioritised. **[1][17][19]**

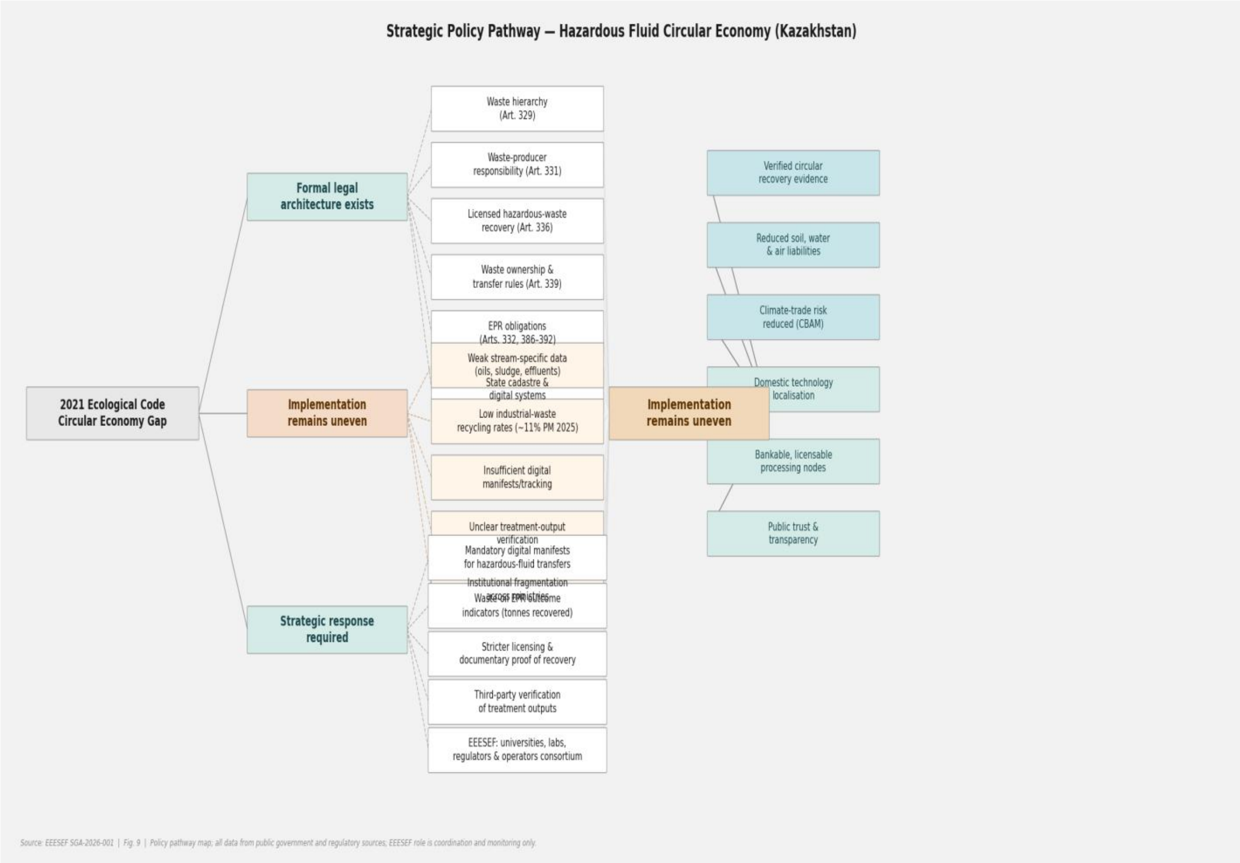

Figure 9: Strategic Policy Pathway — Hazardous Fluid Circular Economy Compliance (Kazakhstan)

5.2 University-Backed Research Consortia & Technology Localisation

The localisation of advanced circular infrastructure cannot be achieved by commercial implementation alone. Kazakhstan needs domestic capacity to test feedstocks, validate technologies, train engineers, maintain equipment, interpret laboratory data, and develop context-specific standards. University-backed research consortia can supply this capacity if they are designed as applied environmental-engineering platforms rather than ceremonial partnerships. **[20][21][29]**

A hazardous-fluid consortium should include at least five functions: first, baseline science — regional sampling of waste oils, sludge, effluents, and residues; second, technology validation — pilot-scale testing of processing systems under Kazakh feedstock conditions; third, compliance translation — converting laboratory results into regulatory indicators and permit conditions; fourth, human-capital development — training students and engineers in hazardous-waste treatment, environmental chemistry, lifecycle assessment, and digital reporting; fifth, public trust — publishing non-commercial findings that regulators, communities, financiers, and industrial operators can evaluate. **[20][21]**

EEESEF serves as convener and public-interest coordinator of such a consortium. The Foundation's role is to organise the framework: aligning stakeholders around shared protocols, preventing single-vendor or single-interest capture of the research agenda, facilitating connections with international cooperation partners, and publishing periodic coordinated status reports that present aggregated findings from the consortium's technical partners. All technical work — laboratory analysis, sampling, validation studies, and peer-reviewed research — is conducted by the relevant university and laboratory partners.

EEESEF neither conducts nor endorses individual technical results; it coordinates the process and ensures its public accountability. The cooperation between EEESEF and participating universities is formalised under a non-binding MoU, completely separate from any industrial research project and its associated funding. The Foundation brings institutional neutrality and coordination capacity; universities bring scientific legitimacy and technical depth; industrial operators provide real feedstock and operational data; and regulators ensure that findings translate into enforceable rules.

Technology localisation also has economic significance. If Kazakhstan only imports turnkey treatment systems, it remains dependent on external suppliers for maintenance, adaptation, spare parts, and intellectual property. If universities and domestic engineering firms participate in validation and adaptation, the country can build local know-how, create patentable process modifications registered as Kazakhstan-developed industrial technology, develop domestic standards, and support local environmental-technology industries. The patent portfolio from such validated process adaptations would be held jointly by the university partner and the technology consortium — with a defined share of patent licensing fees and royalties allocated to the participating university, providing sustainable research income and creating a direct institutional incentive for rigorous scientific engagement. [20][21]

5.3 Implementation Roadmap

The roadmap below deliberately begins with data rather than equipment. A country cannot build a credible hazardous-fluid circular economy if it does not know the types, quantities, locations, and qualities of the fluids moving through its industrial system. The first year should therefore focus on classification, reporting categories, sampling protocols, and pilot manifests. Technology investment should follow the baseline, not precede it. [3][4][14]

Table 4: Strategic Implementation Roadmap — Hazardous-Fluid Circular-Economy Compliance

Phase	Institutional Lead	Core Action	Policy Instrument	Measurable Output
0–6 months: Baseline Design	Ministry of Ecology; Bureau of Statistics; EEESEF; universities	Define hazardous-fluid reporting categories and sampling protocols.	Statistical guidance; technical standard; pilot protocol.	Approved category list for waste oils, oil sludge, oily waters, and refinery effluents.
6–12 months: Digital Pilot	Ministry of Ecology; digital platform operator; selected industrial corridors	Pilot digital manifests for hazardous-fluid transfers in 2–3 priority corridors.	Administrative order; platform extension.	Pilot manifests covering generator, transporter, receiver, waste type, quantity, and treatment method.
12–18 months: EPR Outcome Reporting	EPR authority/operator; producers/importers	Publish waste-oil collection and regeneration indicators for each product category.	EPR annual plan; reporting form.	Annual tonnes placed on market, collected, regenerated, thermally treated, exported, or rejected.

18–24 months: Licensing Transparency	Environmental regulator	Publish licensed hazardous-fluid processors by method, capacity, and permitted waste type.	Licensing register update.	Public operator registry with capacity and scope of license, updated annually.
24–36 months: Validation & Localisation	Universities; EEESEF; operators; finance institutions	Run verified treatment pilots and publish peer-reviewed results. EEESEF coordinates independent oversight.	Research grant; green finance conditions; EEESEF MoU with universities.	Peer-reviewed pilot results, bankable project pipeline, and domestic technology validation registry.
36+ months: National Scale-Up	Government; industry; development partners; EEESEF	Scale compliant processing nodes in priority corridors using validated technologies.	National all-waste concept; investment programme.	Documented increase in regenerated waste oils and verified treatment of oil sludge/effluents with public annual reporting.

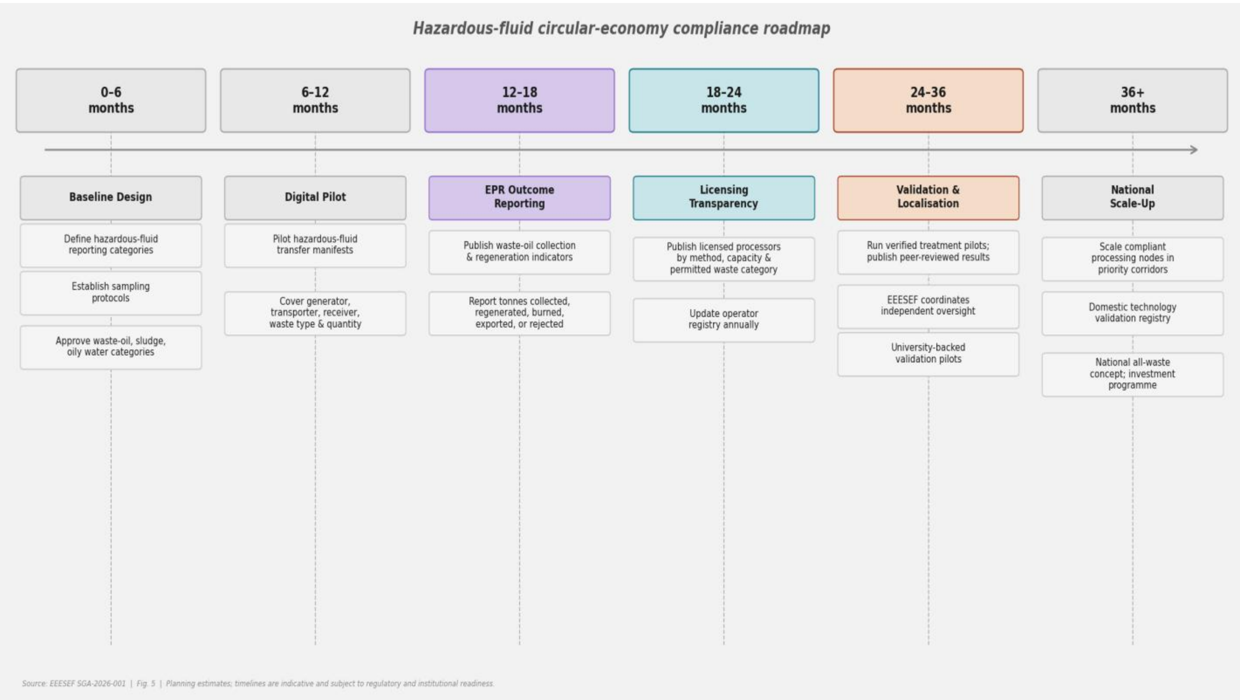

Figure 5: Implementation Roadmap Timeline — Hazardous Fluid Circular Economy Compliance (Kazakhstan)

The second design principle is proportionality. High-risk sludge lagoons and refinery effluents require stronger controls than small quantities of segregated used oil from a well-managed fleet. Digital systems should be scalable, but reporting burdens should match risk and volume. A risk-based design improves compliance because it directs regulatory attention to the pathways most likely to cause environmental harm and economic loss. [1][8][14]

The third design principle is public credibility. If the objective is to reassure regulators, communities, financiers, and export customers, self-reporting alone is insufficient. Third-party verification, university participation, and public reporting by independent foundations should be embedded in the system from the beginning. Transparency is not a public-relations add-on; it is the mechanism through which circular-economy claims become defensible — and through which Kazakhstan's industrial export sectors can credibly demonstrate environmental performance to international markets. [5][6][11][12]

5.4 Consolidated Closing Summary

The evaluation confirms that Kazakhstan's hazardous-fluid circular-economy gap is not primarily a problem of absent legal authority. The 2021 Ecological Code contains the core legal instruments needed for improved management: waste hierarchy, waste-producer responsibility, licensed hazardous-waste processing, ownership and transfer rules, EPR, waste-management programmes, registers, and transparency mechanisms. The central weakness lies in implementation infrastructure: stream-level data, digital traceability, licensed capacity transparency, independent verification, and outcome-based EPR reporting. [1][2][3][4]

The case for advanced physical processing is well-founded and supported by a growing body of peer-reviewed evidence. High-vacuum wiped film distillation technology achieves 84–90% base oil recovery from waste mineral oil without chemical inputs, without generating solid waste, and with complete self-consumption of non-condensable gas as process fuel — figures independently corroborated in peer-reviewed literature on thin-film evaporator performance. This technology profile is directly applicable to Kazakhstan's waste oil streams, pending feedstock-specific pilot validation. The technology provider's economic projections — documented in EEESEF Technical Report TR-001 — indicate strong commercial viability at the 30,000 t/yr scale; those projections require independent validation before being used as the basis for public financing or regulatory decisions. The missing link is not technology or economics; it is the institutional verification architecture that converts vendor claims into bankable, licensable, and independently confirmed certainty. **[17][18][19][20]**

EEESEF is committed to supporting the construction of this institutional architecture in Kazakhstan through its coordination and monitoring mandate. Through its network of university and laboratory partners, its internationally recognised institutional neutrality, its facilitation of stakeholder engagement with Kazakhstan's regulatory bodies, and its programme of coordinated, non-commercial published findings, the Foundation acts as the independent coordinating conscience of the emerging hazardous-fluid circular economy — not by conducting technical work itself, but by ensuring that the technical work conducted by qualified partners is structured, monitored, publicly reported, and free from commercial capture. It does so at no cost to government or to its university and industrial partners, under cooperation MoUs that create no financial or legal obligations on any party. The Foundation's only objective is the measurable environmental outcome — and that singular focus on public interest, uncomplicated by commercial stakes or technical ambitions beyond its mandate, is what makes EEESEF's coordinating presence in this agenda both credible and structurally necessary. [20][21]

By converting legal obligations into measured recovery outcomes, Kazakhstan can reduce soil and groundwater liabilities, improve industrial environmental performance, support domestic environmental-technology capability, and strengthen the credibility of export-oriented sectors under tightening international climate-accounting regimes. Compliance will be achieved not by declaring circularity, but by building the data, licensing, verification, financing, and research systems that make circularity observable — and independently confirmed. [5][6][11][12][20]

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APPROVAL FOR PUBLICATION

This paper has been reviewed and approved for publication by the Euro-Eurasia Environmental Science & Education Foundation (EEESEF).

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