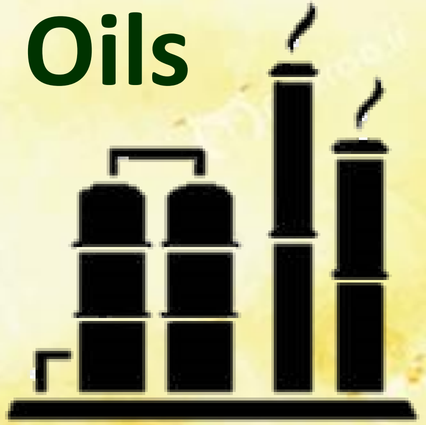
From Waste to Value Re-Refining Used Lubricants into API Group II Base Oils



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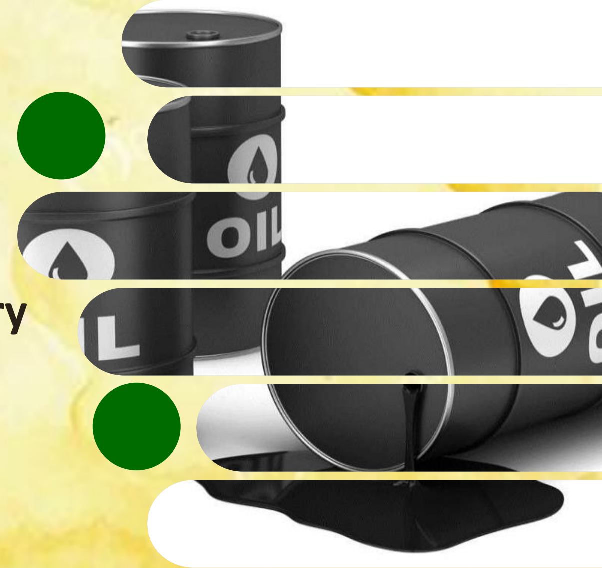
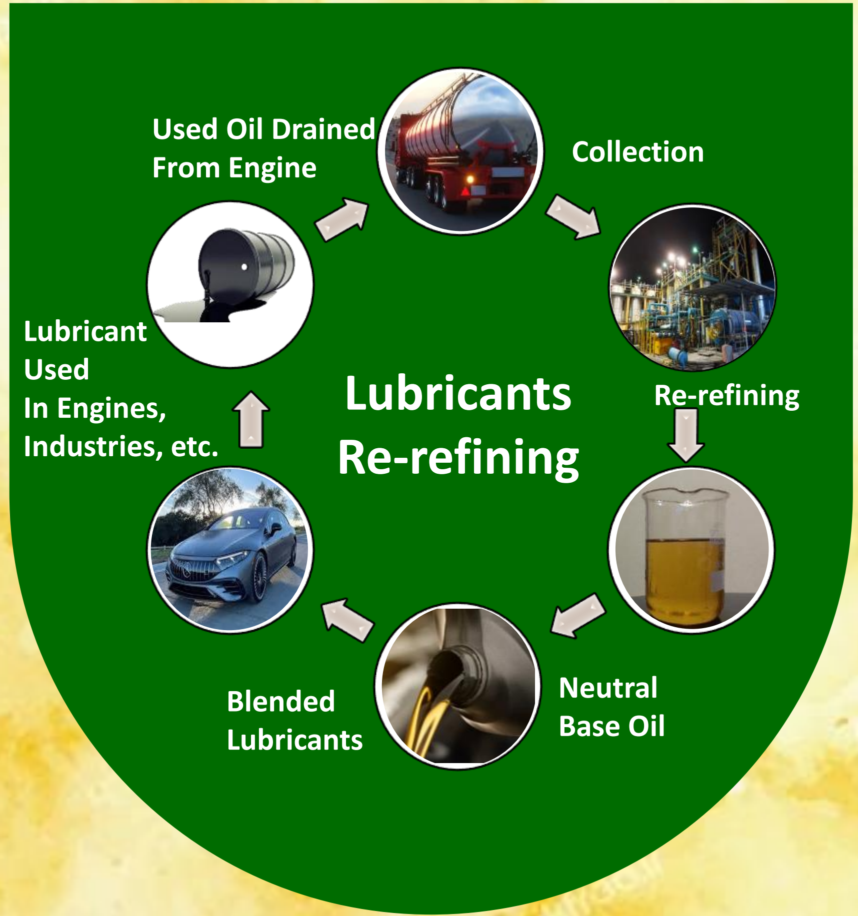
Global Treatment Methods for Used Lubricants

The treatment of used lubricants is a significant environmental and industrial concern globally. The management and treatment practices vary widely depending on the region, regulatory frameworks, and available technologies.

Here's an overview of how used lubricants are treated around the world:





1- Re-refining (Recycling)

- ✓ Process: Used lubricants are processed to remove impurities to produce Base Oil and restore them to a condition where they can be reused.
- ✓ Global Adoption:

- ❖ Europe: Around 50-60% of used lubricants are re-refined.
- ❖ North America: Approximately 40-50% in the U.S. and Canada.
- ❖ Asia: Varies widely; Japan leads with around 50%, while other countries are lower.
- ❖ Global Average: Roughly 40-50% of collected used lubricants are re-refined.

2. Energy Recovery (Burning as Fuel)

- ✓ Process: Used lubricants are burned as fuel in industrial processes, such as in cement kilns or power plants.
- ✓ Environmental Impact: This method releases harmful pollutants if not properly controlled, including heavy metals and carcinogens.
- ✓ Global Adoption:
  - ❖ Europe: Less common due to stricter regulations, with only about 20-30% used in this way.
  - ❖ North America: More prevalent, especially in the U.S., where around 35-45% is used for energy recovery.
  - ❖ Asia and Africa: Higher rates of energy recovery due to lack of re-refining infrastructure, with some estimates suggesting over 50% in certain regions.
  - ❖ Global Average: About 30-40% of used lubricants are burned for energy recovery.

3. Fuel or Diesel Production

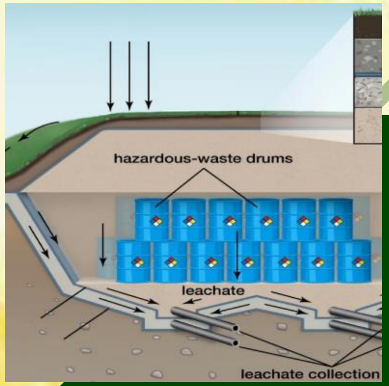
- ✓ Process: Used lubricants are processed into lower-grade fuels or diesel.
- ✓ Environmental Impact: This can lead to high levels of pollutants if not managed properly, and the quality of the resulting fuel can be inconsistent.
- ✓ Global Adoption:
- ❖ Developing Regions: More common in areas lacking advanced re-refining technology. For example, in parts of Asia and Africa, a significant portion may be repurposed in this way.
- ❖ Global Average: Exact statistics are difficult to come by, but it’s estimated that around 10-20% of used lubricants are repurposed as low-grade fuel or diesel.

4. Landfilling

- ✓ Process: Used lubricants are disposed of in landfills.
- ✓ Environmental Impact: Extremely harmful, leading to soil and water contamination, with long-term ecological damage.
- ✓ Global Adoption:
- ❖ Europe and North America: Strongly regulated, with very low percentages (less than 5%) due to stringent environmental laws.
- ❖ Developing Regions: Higher rates of landfilling due to lack of alternatives; estimates suggest 20-30% in some areas.
- ❖ Global Average: Likely less than 10%, but this is more prevalent in regions with weaker regulations.

5. Storage in Landfills (Bulk Storage)

- ✓ Process: Used lubricants are stored in bulk in landfills or dedicated facilities.
- ✓ Environmental Impact: This can lead to leaks and spills, resulting in soil and groundwater contamination.
- ✓ Global Adoption:
- ❖ Developed Regions: Strictly regulated, with storage primarily being a temporary solution before proper treatment.
- ❖ Developing Regions: More common, often due to lack of better options.
- ❖ Global Average: Likely less than 10%, but varies by region.



6. Illegal Dumping or Improper Disposal

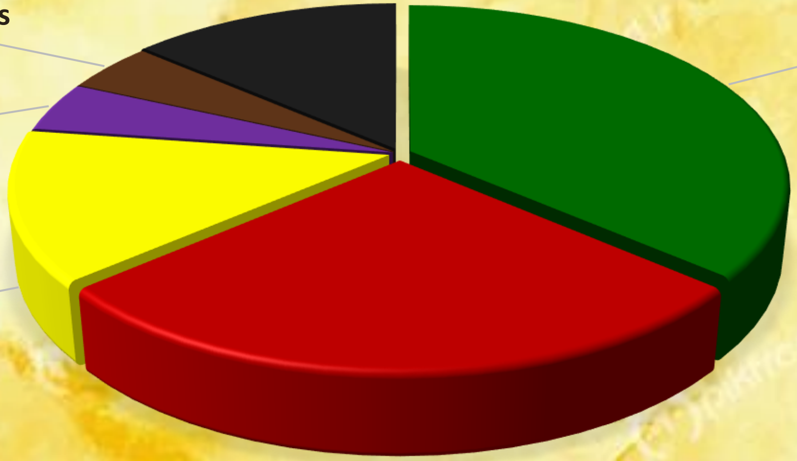
- ✓ Process: Used lubricants disposed in environment illegally.
- ✓ Environmental Impact: Extremely harmful, leading to soil and water contamination, with long-term ecological damage.
- ✓ Global Adoption:
- ❖ Developed Regions: Rare due to strict regulations, though illegal dumping still occurs occasionally.
- ❖ Developing Regions: Unfortunately, this is still a common practice in some areas due to lack of enforcement and infrastructure. Estimates suggest that 20-30% of used lubricants may be disposed of improperly in these regions.
- ❖ Global Average: Likely around 10-20%, with higher rates in regions with weak regulatory frameworks.

Global Statistics and Regional Differences

Europe	North America	Asia	Africa	Latin America
▪ Re-refining: 50-60% ▪ Energy Recovery: 20-30% ▪ Illegal Disposal: <5% ▪ Landfilling and Improper Storage: <5%	▪ Re-refining: 40-50% ▪ Energy Recovery: 35-45% ▪ Illegal Disposal: <10% ▪ Landfilling and Improper Storage: <5%	▪ Re-refining: 20-50% (varies widely by country) ▪ Energy Recovery: 40-50% in some countries ▪ Illegal Disposal: 10-30% ▪ Landfilling and Improper Storage: 10-20%	▪ Re-refining: 10-20% ▪ Energy Recovery: 50-60% ▪ Illegal Disposal: 20-30% ▪ Landfilling and Improper Storage: 20-30%	▪ Re-refining: 20-30% ▪ Energy Recovery: 40-50% ▪ Illegal Disposal: 20-30% ▪ Landfilling and Improper Storage: 20-30%

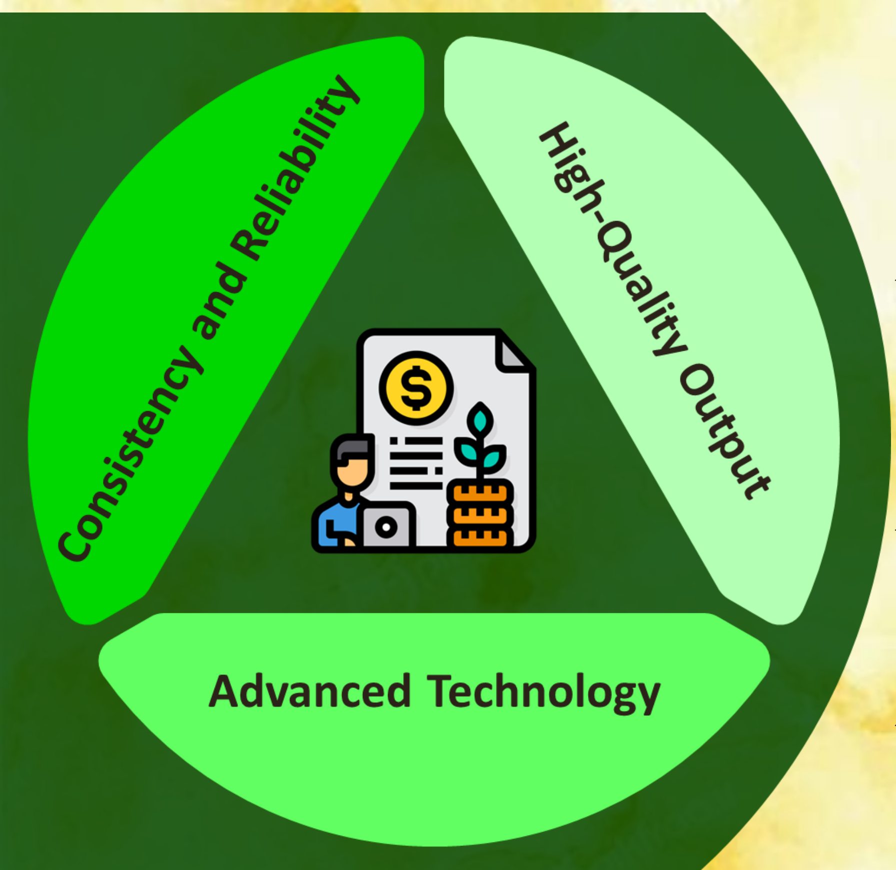
Summary

The treatment of used lubricants varies greatly across the world, with more developed regions leaning towards re-refining and energy recovery, while developing regions struggle with illegal dumping and improper disposal. These practices have significant environmental and health implications, highlighting the need for stronger global regulations and infrastructure development.



The Importance and Advantages of Re-Refining Used Lubricants

Re-refining used lubricants to base oil are offers a multitude of benefits and importance across various dimensions—technical, economic, environmental, and social. Below is a detailed analysis of the advantages of re-refining compared to other methods like burning as fuel, disposal in landfills, or producing low-grade fuels.



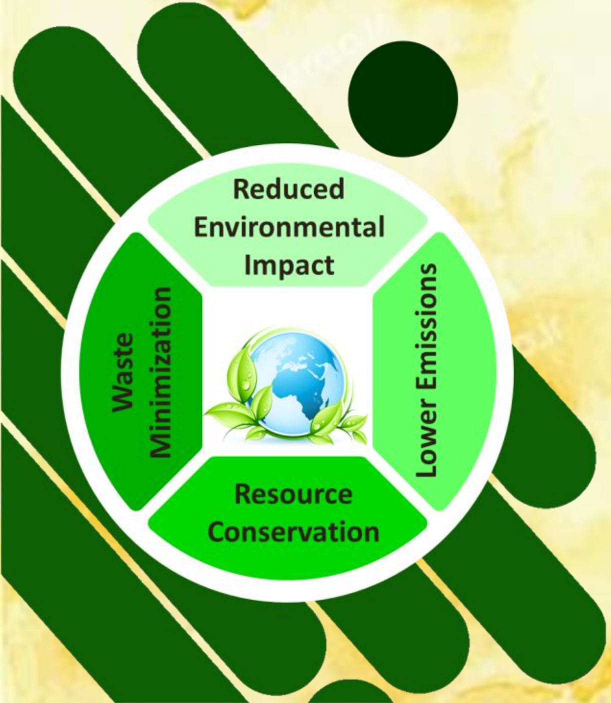
1. Technical Benefits

- ✓ High-Quality Output: Re-refining processes restore used lubricants to nearly the same quality as virgin base oil. The resulting base oil can meet the same specifications and standards, making it suitable for all applications that require high-quality lubricants.
- ✓ Advanced Technology: Modern re-refining technologies, such as hydro treating and vacuum distillation, allow for the removal of impurities, ensuring that the base oil is free from contaminants and meets industry standards.
- ✓ Consistency and Reliability: Unlike fuel recovery or burning, which can produce inconsistent products, re-refining results in a consistent, high-quality product that can be reliably used across industries.

2. Economic Benefits

- ✓ Cost-Effectiveness: Re-refining is generally more cost-effective than producing new base oil from crude oil. The process requires less energy and fewer raw materials, which translates into lower production costs.
- ✓ Profitability: The sale of re-refined base oil can be highly profitable, especially in markets where there is a high demand for lubricants. The lower production costs and the ability to sell at competitive prices make re-refining an economically viable business model.
- ✓ Market Stability: By providing a domestic source of base oil, re-refining can help stabilize the lubricant market in a country, reducing dependence on volatile global oil prices.
- ✓ Job Creation: The re-refining industry requires skilled labor for operations, maintenance, and quality control, leading to the creation of jobs across various sectors, including manufacturing, logistics, and technical services.

3. Environmental Benefits



✓Reduced Environmental Impact: Re-refining significantly reduces the need for virgin base oil production, which involves environmentally harmful extraction and refining processes. It also prevents used lubricants from being disposed of in ways that can contaminate soil and water.

✓Lower Emissions: The re-refining process produces fewer greenhouse gases and pollutants compared to burning used oil as fuel. This helps in reducing the overall carbon footprint of lubricant production and consumption.

✓Resource Conservation: Re-refining conserves natural resources by reducing the demand for crude oil. It also minimizes the generation of waste, contributing to a circular economy where materials are reused rather than discarded.

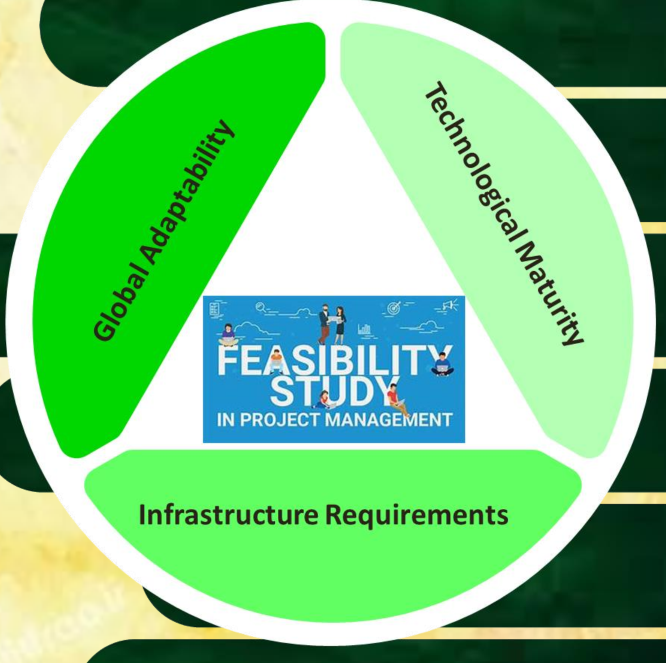
✓Waste Minimization: By converting used oil into reusable base oil, re-refining helps in reducing the volume of hazardous waste that needs to be managed and disposed of, mitigating risks to human health and the environment.

4. Feasibility and Scalability

✓Technological Maturity: Re-refining technology is well-established and can be scaled to meet the needs of different markets, from small-scale operations to large industrial plants.

✓Infrastructure Requirements: While initial capital investment is required to set up re-refining facilities, the ongoing operational costs are lower compared to other disposal or recycling methods. The infrastructure can be integrated into existing industrial areas with access to transportation networks.

✓Global Adaptability: Re-refining can be adapted to various geographical and economic contexts, making it feasible in both developed and developing regions with proper regulatory support and investment.



5. Economic Progress and National Benefits

- ✓ Energy Independence: By reducing the need for imported crude oil, re-refining contributes to a country's energy independence. This is particularly valuable for nations that are not major oil producers.
- ✓ Industrial Growth: The re-refining industry can stimulate growth in related sectors, such as chemical manufacturing, engineering services, and transportation, contributing to overall economic development.
- ✓ Foreign Exchange Savings: Countries that rely on imported oil can save significant amounts of foreign exchange by using domestically re-refined base oil instead of importing virgin base oil.
- ✓ Circular Economy: Re-refining supports the principles of a circular economy, where resources are kept in use for as long as possible, extracting maximum value before recovery and regeneration. This promotes sustainable economic growth and reduces waste.

6. Energy Aspects

✓Energy Efficiency: Re-refining used oil requires less energy compared to refining crude oil into base oil. The energy savings can be substantial, contributing to lower overall energy consumption in the economy.

✓Reduced Energy Costs: Lower energy requirements translate into reduced operational costs for re-refining facilities, which can be passed on as cost savings to end-users.

✓Renewable Energy Integration: Re-refining plants can be designed to integrate renewable energy sources, further enhancing their environmental and economic benefits.

7. Social and Regulatory Aspects

✓Health and Safety: Re-refining used oil prevents the release of harmful substances into the environment, reducing risks to public health and safety compared to methods like burning or illegal dumping.

✓Regulatory Compliance: Many countries have regulations that encourage or mandate the re-refining of used oil. Complying with these regulations not only avoids legal penalties but can also provide financial incentives, such as tax breaks or subsidies.

✓Corporate Responsibility: Companies engaged in re-refining can enhance their corporate image by demonstrating a commitment to sustainability and environmental stewardship, which can be a competitive advantage in today’s market.

8. Research and Development

- ✓ Innovation Potential: Re-refining is a field ripe for innovation, with ongoing research into more efficient processes, better catalysts, and more sustainable practices. This can lead to technological advancements that further reduce costs and environmental impacts.
- ✓ Knowledge and Skill Development: The re-refining industry contributes to the development of specialized knowledge and skills, supporting educational institutions and creating a skilled workforce.

Summary

- ✓ Re-refining used lubricants to base oil presents numerous advantages over other methods such as burning, disposal, or conversion to low-grade fuels. It is technically feasible, economically viable, environmentally sustainable, and socially responsible. By adopting re-refining practices, countries can reduce their dependence on imported oil, create jobs, stimulate economic growth, and contribute to global efforts to reduce environmental degradation and promote sustainable development.

Key Processes for Re-Refining Used Lubricants

Re-refining of used lubricants involves various processes to remove contaminants and restore the oil to a usable condition. The choice of process depends on factors like feed capacity, available technology, and economic considerations. Here's a comprehensive overview of the main processes used globally, categorized by low, medium, and high feed capacities:

1. Capacity Definitions

Low Capacity:	Medium Capacity:	High Capacity:
Up to 10,000 tons per year (TPY). Typically used in smaller markets or regions with limited access to used oil.	10,000 to 50,000 TPY. Common in medium-sized markets or countries with moderate used oil recovery infrastructure.	Over 50,000 TPY. Found in large, industrialized countries or regions with well-established used oil recovery systems.

2. Main Processes for Re-refining of Used Lubricants

A. Acid-Clay Treatment

- Process Overview:
  - ❖ Acid Treatment: Used oil is treated with sulfuric acid, which removes impurities by forming sludge.
  - ❖ Clay Treatment: The oil is then filtered through clay to remove any remaining contaminants and improve color.
- Global Usage:
  - ❖ Low-Capacity: Predominantly used in small-scale operations, particularly in developing countries due to its low cost and simplicity.
- Advantages: Simple and low-cost, requires minimal investment.
- Disadvantages: Generates hazardous waste (acid sludge), lower oil quality, environmental concerns.
- Regions: Still used in some parts of Africa, Asia, and Latin America.
- Capacity: Typically, under 10,000 TPY.

B. Distillation-Clay Process

- Process Overview:
  - ❖ Distillation: The used oil is distilled to separate it into different fractions based on boiling points, removing water and light hydrocarbons.
  - ❖ Clay Treatment: After distillation, the oil is treated with clay to remove remaining impurities.
- Global Usage:
  - ❖ Low to Medium Capacity: Common in developing regions where simple, cost-effective solutions are needed.
- Advantages: Produces higher-quality oil than acid-clay,(the best obtained quality is API Group I), lower environmental impact.
- Disadvantages: Clay usage still generates waste, moderate investment required.
- Regions: Used in parts of Asia and South America.
- Capacity: Typically, 5,000 to 30,000 TPY.

C. Vacuum Distillation & Solvent Extraction

- Process Overview:

❖ Used oil is heated under reduced pressure (vacuum), which lowers the boiling point and allows separation of oil fractions at lower temperatures, preserving the quality of the base oil, then A solvent, usually N-Methyl-2-pyrrolidone (NMP) is used to selectively dissolve and remove contaminants from the used oil. The solvent is then separated from the clean oil and reused.

- Global Usage:

❖ Medium to High Capacity: Used in regions with requirement of better-quality requirements for re-refined oils.

- Advantages: Produces high-purity base oil, solvent is recoverable and reusable.
- Disadvantages: Complex process, high investment, solvent handling required. Usage of some solvents are not allowed in some countries (not safe for human health) n Lower base oil quality (better than acid clay, the best obtained quality is API Group I
- Regions: Applied in Europe and North America where a better output quality is essential.
- Capacity: Typically, 10,000 to 70,000 TPY.

D. Multi-Stage Vacuum Distillation & Polishing by Aluminum based Reactivable Adsorbent

- Process Overview:

  This advanced re-refining process combines several steps, starting with caustic conditioning and moving through multiple stages of vacuum distillation, followed by final polishing with a reactivable aluminum-based adsorbent like reactivate aluminum base adsorbent

- Global Usage:

  ❖ Low to Medium Capacity: Used in regions with high quality for re-refined oils but in lower capacity and lower investment cost

- Advantages: Produces high-purity base oil comparable to virgin oil, (API Group II quality can be obtained) Energy Efficiency. Environmental Sustainability. minimal waste, Adsorbent is receivable and reusable up to 500 time before replacement, Flexibility, versatile process, capable of handling various feedstock qualities and adaptable to different capacities, making it suitable for small to medium-sized operations.
- Disadvantages: Complex process, higher investment cost to acid clay process. Not proper for high capacities
- Regions: Applied in Asia and North America where high-quality output is essential in lower capacity.
- Capacity: Typically, 3,000 to 50,000 TPY.

E. Vacuum Distillation & Hydro processing (Hydro treating)

- Process Overview:
  Used oil is heated under reduced pressure (vacuum), which lowers the boiling point and allows separation of oil fractions at lower temperatures, preserving the quality of the base oil, then distilled oil is treated with hydrogen under high pressure and temperature in the presence of a catalyst. This removes sulfur, nitrogen, and other impurities, saturating unsaturated hydrocarbons.
- Global Usage:
- High Capacity: One of the most advanced re-refining methods, suitable for large-scale operations.
- Advantages: Produces high-quality, low-sulfur base oil that meets stringent specifications, long operational life of the catalyst.
- Disadvantages: High capital and operating costs, complex operation. High operation cost, sensitive catalyst to existence of calcium, silicon, zinc and phosphor in the oil that reduce its life, expensive catalyst, high demand to electrical energy to produce Nitrogen
- Regions: Common in North America, Europe, and Japan, where high quality and environmental standards are prioritized.
- Capacity: Typically, 50,000 to 200,000 TPY or more.

F. Membrane Technology

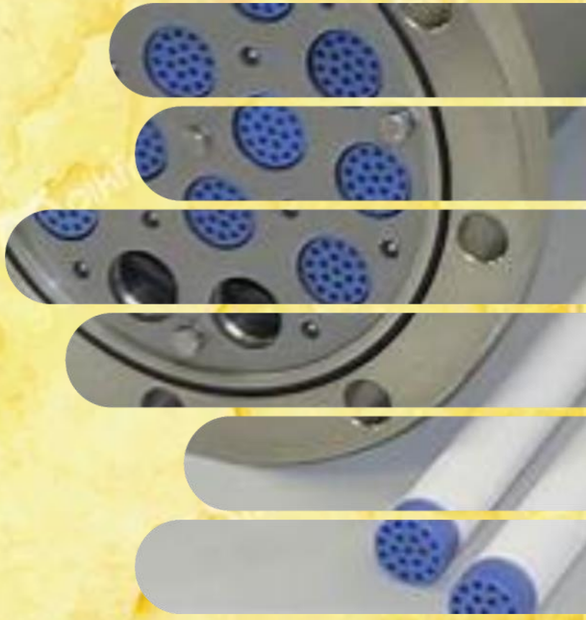
- Process Overview:

❖ Membrane Filtration: Used oil is passed through membranes that selectively separate contaminants based on size or chemical properties. This can be combined with other processes like distillation or hydro processing.

- Global Usage:

❖ Low to Medium Capacity: Emerging technology with potential for growth, currently more experimental or used in specialized applications.

- Advantages: High efficiency, minimal waste generation, energy-efficient.
- Disadvantages: Still under development, high initial costs, membrane fouling.
- Regions: Mostly in pilot projects or specialized facilities in Europe and North America.
- Capacity: Typically, 5,000 to 30,000 TPY.



3. Comparison by Capacity and Region

- Low Capacity (<10,000 TPY):

❖ Processes: Acid-Clay, Distillation-Clay,

❖ Regions: Developing countries, small-scale operations in Asia, Africa, and Latin America.

❖ Characteristics: Low investment, simple technology, environmentally concerning in some cases.

- Low & Medium Capacity (<50,000 TPY):

❖ Processes: Multi-Stage Vacuum Distillation & Polishing by Aluminum based Reactivable Adsorbent

❖ Regions: North America, developed countries & developing countries (all of the world)

❖ Characteristics: medium investment, complex technology, environmentally friendly, high quality base oil in low and medium capacity with reasonable investment cost, Low period for return of capital

- Medium Capacity (10,000-50,000 TPY):

❖ Processes: Vacuum Distillation & Solvent Extraction,

❖ Regions: Developing and developed countries with moderate infrastructure, parts of Asia, and South America.

❖ Characteristics: Balanced between investment and output quality, moderate environmental impact.

- High Capacity (>50,000 TPY):

❖ Processes: Vacuum Distillation Hydro processing, and sometimes Solvent Extraction

❖ Regions: North America, Europe, Japan, advanced re-refining facilities globally.

❖ Characteristics: High investment, advanced technology, high-quality output, environmentally sustainable.

Summary

✓Re-refining used lubricants involves a range of processes, each suited to different capacities and regional needs. Acid-Clay and Distillation-Clay processes are more common in low-capacity operations, particularly in developing regions

✓Multi-Stage Vacuum Distillation & Polishing by Aluminum based Reactivable Adsorbent is a environment friendly process that can be used in all of the world for low and medium capacities with high quality product and reasonable investment cost

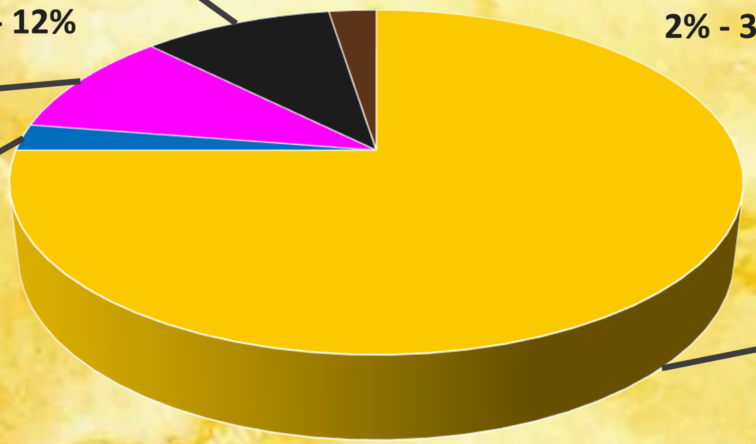
✓Vacuum Distillation, with Solvent Extraction or Hydro processing are prevalent in medium to high-capacity facilities, especially in developed countries where environmental regulations and product quality standards are higher. The choice of process depends on factors like available technology, economic viability, environmental impact, and regional market demands.

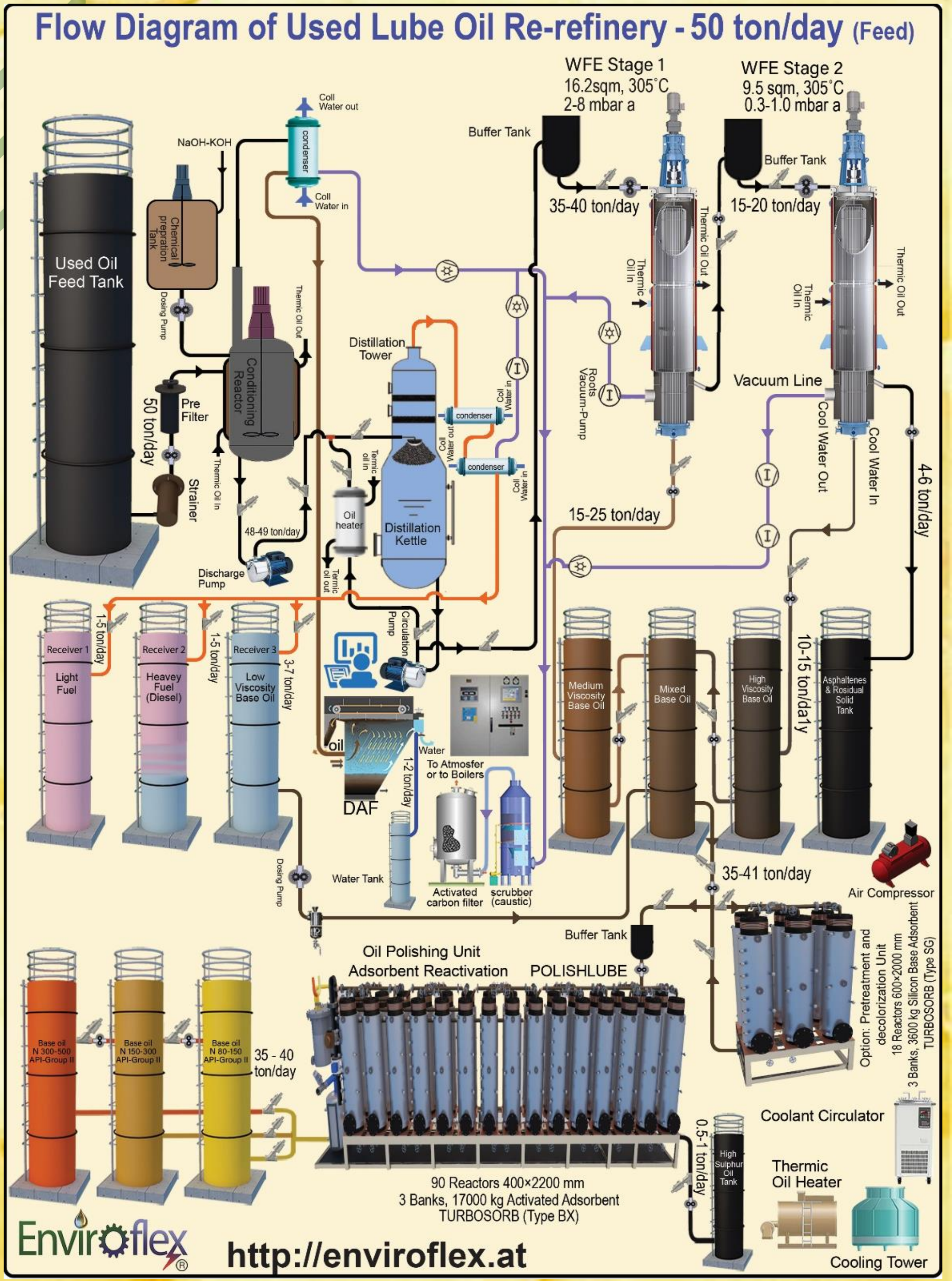
Proposed Process for Re-Refining Base Oils

✓Multi-Stage Vacuum Distillation & Polishing by Aluminum based Reactivable Adsorbent is an environmentally friendly process selected and suggested here, The main advantages area

- ❖Environmentally friendly process
- ❖High qualia base oil (API Group II)
- ❖Zero discharge
- ❖Acceptable and reasonable Investment capital
- ❖Low operational cost
- ❖Economical feasible project, Short Investment payback period and high Internal rate of return (IRR)
- ❖Proper for all of the regions of the world with for low and medium capacities

Typical Percentage of extracted products of refining of used oil





1. Caustic Conditioning and Water Removal

Caustic Conditioning:

The process begins by mixing the used lubricants with a caustic agent, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), under a low vacuum. This step helps neutralize acidic contaminants and remove any residual water.

Heating and Mixing:

The mixture is heated while being continuously stirred, which ensures uniform treatment and aids in breaking down complex contaminants.

Water Removal:

As the mixture is heated under low vacuum, water and other light volatiles are evaporated and removed. This step also helps in stabilizing the used oil for subsequent processing.

2. Distillation in Distillation Columns

- ✓ Medium Vacuum Distillation: The conditioned oil is then fed into distillation columns operating under medium vacuum pressures. The distillation is done in stages, where lighter fractions (like naphtha and diesel-like fuels) are removed first, followed by heavier fractions.

- ✓ Precise Separation: The process uses precise control over vacuum pressures and temperatures to separate different fractions effectively, ensuring that each fraction is distilled at the optimal temperature for maximum recovery.

3. Wiped Film Short Path Evaporation

- • **High Vacuum Evaporation:** The oil then undergoes evaporation and distillation in wiped film or short path evaporators, operating under high vacuum conditions (0.2 to 8 mbar) and temperatures up to 305°C.
- •**Wiped Film ShortßPath Evaporators:** These evaporators are designed to minimize the residence time of the oil at high temperatures, reducing the risk of thermal degradation (cracking). The wiped film ensures a thin layer of oil is continuously wiped off, enhancing heat transfer and efficient separation of high-boiling fractions.
- •**Multi-Stage Distillation:** Typically conducted in 1 to 3 stages, this step refines the oil into different grades of base oils, removing heavy residues and ensuring a high-quality output.

4. Polishing with Aluminum based adsorbent

- **Adsorption Polishing:** The final step involves polishing the distilled oil using reactivable aluminum-based adsorbent, such as bauxite. This step removes any remaining impurities, such as color bodies and trace contaminants, resulting in a clear and stable base oil.
- **Reactivable Adsorbent:** The bauxite can be reactivated and reused multiple times, making the process more sustainable and cost-effective.

Advantages of the Process

High-Quality Base Oil:	Energy Efficiency:	Environmental Sustainability:	Flexibility:
The multi-stage distillation and polishing produce a high-quality base oil, comparable to virgin oil, meeting stringent industry standards. Up API Group II	The use of high vacuum in the wiped film evaporators allows for lower distillation temperatures, reducing energy consumption and minimizing thermal degradation of the oil.	The process generates minimal waste, and the reactivation of bauxite adsorbent contributes to the sustainability of the operation.	This process is versatile, capable of handling various feedstock(mineral based used lubricants, synthetic based used lubricants and mixture) qualities and adaptable to different capacities, making it suitable for small to medium-sized operations.

Market Adoption and Share

- ✓ Emerging Process: This re-refining process is relatively new and gaining traction in markets where there is a demand for high-quality re-refined base oil, particularly in small to medium-sized operations.

- ✓ Low to Medium Capacities: The process is especially suited for facilities with capacities up to 100 tons per day (3,000 to 50,000 TPY), making it attractive to small and medium enterprises (SMEs) in the re-refining sector.

Global Presence:

North America:	Europe:	Asia and Latin America:	Middle East and Africa:
North America: The process is increasingly adopted in these regions due to stringent environmental regulations and the high demand for high-quality base oil. Small and medium-sized plants in these areas are shifting towards this method because of its efficiency and environmental benefits.	new for this reign butt suggested for this region especially for Eastern Europe that capacities and investment are lower	Adoption is growing in emerging markets where there is a need for cost-effective yet environmentally sound re-refining processes. These regions often have lower initial investment capacities, and this process offers a good balance of investment and output quality.	The process is also being introduced in regions with developing re-refining industries, where there is interest in establishing local recycling facilities to reduce dependency on imports and manage waste oil domestically.

Challenges and Considerations

- ✓ Initial Investment: Although this process is more cost-effective than large-scale re-refining operations, it still requires a significant initial investment in equipment like vacuum distillation columns and wiped film evaporators.
- ✓ Technical Expertise: The process requires skilled operators and proper maintenance to ensure the equipment functions efficiently and the quality of the output is maintained.
- ✓ Market Penetration: As the process is relatively new, its market share is still growing. Adoption is more common in regions where environmental regulations drive the need for high-quality re-refined oil and where there is sufficient economic incentive.

Summary

This advanced re-refining process, which combines caustic conditioning, multi-stage vacuum distillation, wiped film short path evaporation, and bauxite polishing, is becoming increasingly popular in low to medium-capacity operations globally. It offers a high-quality output with significant environmental and economic benefits, making it a promising option for markets looking to upgrade their used oil recycling capabilities. Its adoption is particularly strong in regions with stringent environmental regulations and a growing demand for sustainable and high-quality base oils.

Polishing Technology for Distilled Lube Oil Using Reactivable Aluminum-Based Adsorbents to Achieve API Group II Standards

- The suggested process in last section for used oil Re-refineries consist of several Distillation/Evaporation stages in low and very high vacuum, then Distilled Oil is treated in Treatment & Polishing Plants by reactivable Adsorbent
- An adsorbent is used to remove trace substances from fluids. These trace substances attach themselves to the surface of the adsorbent through van der Waals forces.
- The technical adsorbents used in laboratory practice and especially in exhaust gas purification and distilled lube oil regeneration applications
- The color, sulfur, acidity, and aromatic contents of oil are reduced to produce Base Oil as per API Group II and even some times with quality API Group III (when feedstock consists of big percentage of synthetic oil with high viscosity index). The adsorbent is reactivated several times by these plants before replacement.

Specification of the Polished Oil

- ✓ Color < 1.0, as per ASTM D-1500
- ✓ Sulfur < 300 ppm, as per ASTM D-2622
- ✓ Acidity < 0.01 mg KOH/g, as per ASTM D-974
- ✓ Aromatic < 2.0%, as per ASTM D-2007
- ✓ Ester content approx. Zero
- ✓ No Smell, No Re-turbidity

- These plants are delivered to treat and polish oil in different capacities in range of 0.2 to 70 ton per day. They are designed to meet the following operational requirements for processed and polished oil.
- The reduction of Sulfur content
- The reduction of Color, white to light-yellow
- The reduction of Aromatic and removal of bad smell
- The reduction of Acidity of base oil
- The removal of Ester Content
- The removal of Particulate Matter and Dirt

The unique feature that distinguishes that new polishing plants (POLISHLUBE) with usage of aluminum Based Adsorbents ((TURBOSORB) compared to conventional oil polishing plants that used Silicon based adsorbents (Fuller Earth Clay) is the ability to treat, polish, and clarify the distilled oil continuously using a cyclic program that reactivates the absorbent inside the reactors after oil polishing is completed. The cyclic program consists of three stages Filling, Oil Polishing and Sorbent Reactivation. The Reactivation of Sorbent is fully automated and enables the polishing plant to process oil again and again,150 to 500 times before sorbent replacement. Such plants usually consist of some Modules on some frameworks:

- Oil Polishing Reactors Modules (Banks)
- Feed Module
- Sorbent Reactivation Module
- Control Module

Another unique feature of such new plants is the usage of Reactors (Jacketed columns) made of boiler grade steel, instead of simple columns.
The operational cost of such new Plants is very low.
If we consider a used lubricant Re-refinery with a feed capacity of 32 tons/day (10000 tons per year feed) and output capacity of 25 ton per day (7800 ton per year output of base oil), the operational costs for a such plant per one ton of produced Base Oil are:

- Approx. 6.0 EUR/ton for the adsorbent and other consumable materials & parts
- Approx. 10 EUR/ton for energy cost
- Approx. 8 EUR/ton for required operational staff
- Total: Approx. only 24 EUR/ton of produced base oil (totally about 187,000 EUR/year)

Some high sulfur content oil, called Scrap-Oil, is extracted during the end of the sorbent reactivation stage. The amount of the Scrap-Oil is 0.5 to 1.5% of the feed oil to the polishing plant. The Scrap Oil is not considered a waste, as it can be reprocessed in the distillation unit of the Re-refinery.

Aluminum Based Activated sorbent (TURBOSORB-Bx) series are adsorbents consisting of Aluminium Oxide-gamma. It has been used for Polishing of Black Distilled Lube oil as well as in the petrochemical industry and for fuel jet clarification. Another important application is paraffin and naphthenic insulation oil regeneration used in transformers. Both applications use the percolation process. The Capacity is 1.5 to 3 kg of oil can be passed through 1 kg of TURBOSORB-Bx-Series before sorbent saturation Reactivation method: isa Thermal, Electrical, process possible up to 500 time

Benefits and Methods of Transformer Oil Regeneration

✓Transformer oil is a crucial component in electrical transformers, serving as both an insulator and a coolant. Over time, however, the oil can degrade due to various factors, including exposure to heat, oxygen, and electrical stress. Regenerating transformer oil is essential to maintaining the efficiency, safety, and longevity of transformers. Here are the key benefits and reasons why transformer oil regeneration is necessary:

1. Restoring Oil Properties:	2. Extending Transformer Life:	3. Cost Savings:	4. Environmental Benefits:
❖ Insulation: Transformer oil provides electrical insulation between transformer windings and the tank, preventing electrical breakdown. Regeneration helps restore the oil's dielectric strength by removing impurities like acids, moisture, and particulate matter. ❖ Cooling: The oil also acts as a coolant, dissipating heat generated during operation. Regeneration helps maintain the oil's thermal conductivity, ensuring efficient cooling of the transformer.	❖ Reducing Wear: Degradation products like acids, sludge, and oxidation compounds can cause corrosion and wear on internal transformer components. Regenerating the oil reduces these harmful substances, thereby extending the life of the transformer. ❖ Preventing Failures: Degraded oil can lead to insulation failure, overheating, and even catastrophic transformer failures. Regular oil regeneration helps prevent such issues by maintaining oil quality.	❖ Economic Efficiency: Replacing transformer oil entirely can be expensive, especially in large transformers. Regeneration is a cost-effective alternative that allows for the reuse of existing oil, reducing the need for costly new oil purchases. ❖ Minimized Downtime: Regular oil regeneration reduces the frequency of maintenance and repairs, leading to less downtime and higher operational efficiency. ❖ Minimized stop of operation. oil regeneration on Energized transformer prevents from few days stop op operation of transformer to discharge the oil, clean and replace the old oil with new oil	❖ Waste Reduction: By regenerating and reusing transformer oil, the amount of waste oil that needs to be disposed of is significantly reduced. This helps minimize the environmental impact associated with the disposal of used oil. ❖ Sustainable Practice: Regeneration is a more sustainable practice compared to oil disposal and replacement. It conserves resources and reduces the carbon footprint associated with the production and transport of new oil.

Conclusion

In summary, the global treatment of used lubricants presents both challenges and opportunities. Re-refining offers a sustainable path, delivering economic and environmental benefits while maintaining lubricant quality.

Multi-Stage Vacuum Distillation & Polishing by Aluminum based Reactivable Adsorbent presents an optimal solution for medium-capacity operations across various regions. This approach allows for the production of high-quality base oils with a significantly lower investment and operational cost compared to larger refineries. The process is both

profitable and feasible, offering a zero-discharge, environmentally friendly solution. Its flexibility and efficiency make it a preferred choice for many regions, ensuring sustainable and economically viable operations that meet local demand without compromising on quality.

Regenerating transformer oil using Aluminum based Adsorbent effectively restores the oil's quality, extending the life of transformers while reducing waste and environmental impact. This process is cost-efficient, environmentally sustainable, and capable of removing impurities, ensuring the transformer oil meets high-performance standards. As a result, transformer oil regeneration with bauxite is a reliable and eco-friendly solution that supports the long-term reliability of electrical infrastructure.

I am Ali Ebrahimpour, Managing Director of Enviroflex GmbH located in Austria and Germany, a leader in innovative oil re-refining solutions and manufacturing of Distilled Oil Polishing Plants called POLISHLUBE to treat oil by usage our Aluminum based Adsorbent called TURBOSORB. We also manufacture Transformer Oil Purification and Regeneration Plants
Our brands are dedicated to providing sustainable and high-performance used oil treatment products, setting new industry standards for quality and environmental responsibility.
We pride ourselves on our commitment to excellence and our contribution to a cleaner, more efficient future.
Wish all the best.
Dr. Ali Ebrahimpour