RECENT DEVELOPMENTS IN RE-REFINED LUBRICANT TECHNOLOGY

Introduction

In our current energy crisis, much importance is placed on reusable oils. While fossil fuels have been the primary fuel source of many global industries, they have become increasingly scarce. According to the U.S. Energy Information Association, the global supply of crude oil and other liquid fuels will sufficiently cover the world's demand for crude oil up to the year 2050, granted that global demand continues its current upward trend[1]. Thus, renewable oil is imperative to mitigate and circumvent the exhaustion of finite energy sources.

As a solution, many companies are now looking towards re-refined lubricants, also known as re-refined oils. Unlike standard refined oils, re-refined oils recapture and refine used oil to offer a renewable, eco-friendly, and competitively priced alternative to existing oils and lubricants. While re-refined lubricants are versatile enough to cover a wide variety of industrial oils, their primary use is in automotive oil, as it holds the largest market share for re-refined base oils, according to a 2022 market outlook and forecast report by the official Research and Markets research store[2]. Furthermore, the market size of re-refined oils trends towards accelerating growth, with a Technavio report of the re-refined oil market for 2023-2027 predicting a $2.281 billion growth in the market at a compounded annual growth rate (CAGR) of nearly 6.26%, as shown below in Figure 1[3].

This optimistic growth rate is predicated on numerous driving factors, including market trends that have driven a demand for high-quality oils with lower environmental impact. Also, this demand has encouraged numerous government-issued policies to shift used oil collection and consumption to a more eco-friendly direction. Primarily in the past three years, the field of re-refined lubricants has experienced a stark growth in part due to these trends and a general improvement in refinement and quality control. This article catalogs numerous innovations and policies that have facilitated this growth, paying close attention to their positive impact on the process of re-refinement and their implications towards a general trend for the future of re-refined oils.

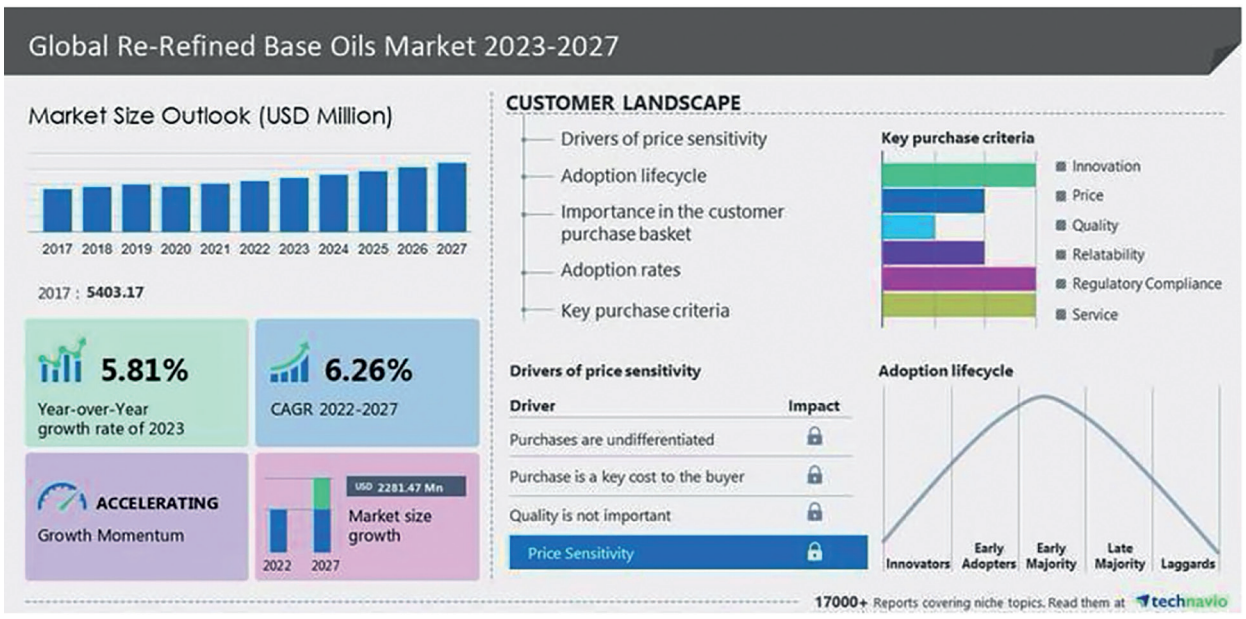

Figure 1: A graphical representation of Technavio's 2023 report on the predicted trends and growth of the global re-refined base oils market from 2023-2027[3].

Origin, Sources of Growth, and Oil Groups

While oil re-refining has recently received a new surge of financial and political backing, commercial production methods have been utilized in the past. The standardized commercial method of hydrotreatment emerged in the 1980s with the Phillips Re-refined Oil Process (PROP)[4], and later additions of vacuum distillation cementing the process as an industry standard. While this process was implemented throughout industries, the boom in U.S. oil production in 2008 and various policies like the Congressional Renewable Fuel Program in 2005[5] prompted vast incentives for renewable oil research. Thus, oil re-refining has a history of technological advancements and government aid to ensure its continuous growth into a modern pillar of alternative oils.

Re-refined base oils fall into one of five different groups, as shown in Table 1. In the global market, Group II oil is most prevalent, as its low sulfur content and low viscosity are far more preferential to automotive and industrial lubricant manufacturers[3]. Because they have a low viscosity index, Group II oils maintain effective lubrication over wider temperature ranges while producing less carbon emissions compared to standard motor oil. If this group can be further developed, Group II re-refined oils will have the potential to supplant traditional automotive lubricants, providing a cleaner and more efficient oil at more competitive prices. Thus, as more countries pivot toward re-refined oils, more funding and attention are funneled into collection and development programs, providing the necessary income and prevalence to cement re-refined oils as a competent alternative to traditional lubricants.

Table 1: The qualities and contents of every Group of re-refined base oil[6].

	API BASE OIL CATEGORIES				
	Base Oil Category	Sulfur (%)		Saturates (%)	Viscosity Index
Mineral	Group I (solvent refined)	>0.03	and/or	<90	80 to 120
Mineral	Group II (hydrotreated)	<0.03	and	>90	80 to 120
Mineral	Group III (hydrocracked)	<0.03	and	>90	>120
Synthetic	Group IV	PAO Synthetic Lubricants			
Synthetic	Group V	All other base oils not included in Groups I, II, III or IV			

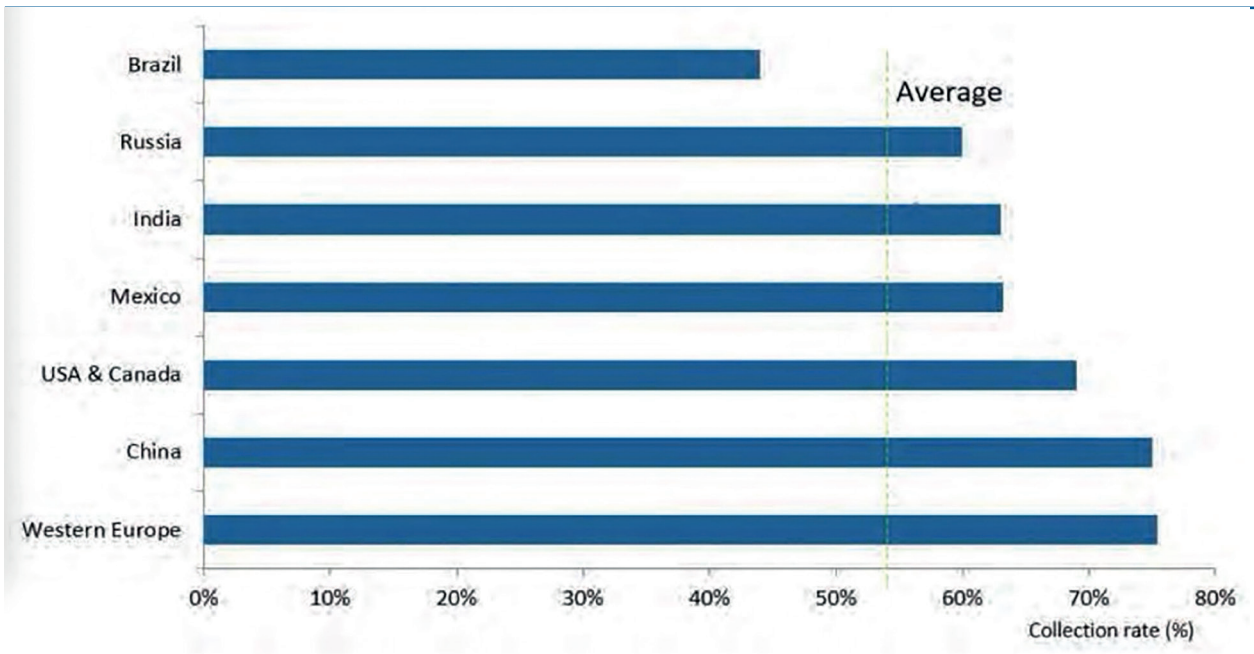

Figure 2: The collection rates of used oil in eight different markets of varying degrees of development in 2019[7].

Global Relevance and Obstacles

On a global scale, the re-refined oils market holds the largest share in developed regions like North America and Western Europe, as these markets possess the infrastructure to support programs facilitating the production of high-quality re-refined oils[7]. Because these areas are well-supported by strong governments and existing production companies, they have the power to collect large quantities of used oil and construct used oil processing plants dedicated to creating a quality fuel source. North America, in particular, holds the largest market share by far, accounting for 34% of global revenue in 2022[2]. This dominance in the market is due to many factors: developed infrastructure, supportive government measures, and the presence of major vendors including Universal Lubricants, Valvoline, and Safety Kleen[2].

However, these market trends reflect the major flaw with re-refined oils. Aside from the costly re-refinement process, a major challenge impeding the growth of re-refined oils is the collection of used oils[2]. Because oil is so widely employed, spent oil becomes equally ubiquitous, making its collection and delivery extremely difficult without a large-scale transportation and collection system. Equally difficult is the high cost of transporting large quantities of oil across long distances, not to mention the cost of creating facilities for the exclusive treatment of spent oil. The high costs of each step and the necessity of infrastructure leave re-refined oil processing inaccessible for developing countries. Even for developed countries, the infrastructure requirement of used oil collection is a daunting task that requires constant attention and research input. As shown in Figure 2, not even the most developed countries can collect all of the used oil throughout their nations. The largest countries, Western Europe and China, can only manage 75% collection as of 2019.

Global Government Policies

Given such a daunting task, numerous countries have implemented policies to curb the difficulty of used oil collection or incentivize the production of re-refined oils. For example, Turkey's Ministry of Environment drafted further regulations regarding the disposal of used oil in 2022[8]. Fueled by its ongoing "zero waste" recycling program launched in 2017, the Turkish government had begun regulating the recycling of used cooking oil, which was typically dumped into the soil or the sea[8]. Their policies banned the import of used cooking oil and taxed collectors who improperly disposed of their oil rather than recycling it[8]. Instead of just enforcing a fine, the government also tasked municipalities with preventing improper disposal and required the oil producers to provide households with the proper equipment to supply used oils8. Additionally, the regulation also set standards for re-refining facilities using those oils, establishing the framework for facility construction. Further proving Turkey's dedication to re-refined oils is the continued operation of its domestic Tayras waste oil re-refinery, a facility that began operations in 2021 and has continued to collect waste oils and manufacture re-refined base oils ever since[9]. Of the 580,000 metric tons of lubricant consumed by Turkey in 2022, an estimated 280,000 tons were collected and 110,000 tons were processed into re-refined oils; an increase from the 95,000 tons processed in 2021[10]. With a unified collection system followed by an in-house re-refinery plant, Turkey is well-positioned to become a strong producer of re-refined base oils.

Another attempt to curb the difficulties associated with used oil collection is seen with India's government extending the reach of its Extended Producer Responsibility (EPR) scheme to include used oils in 2023[11]. Introduced in 2016, the EPR ensured that producers were in charge of a product throughout its entire lifecycle, necessitating proper packaging, collection, and disposal[12]; Figure 3 below shows this product lifecycle under the EPR. As a result, the EPR is a strategy to improve waste management and environmental pollution while ensuring sustainable business practices like reliable packaging to ensure product quality during transportation. Regularly, India has extended this responsibility to various other producers, most recently to used oils.

Proposed to begin in April 2024, companies in India that produce, collect, recycle, or import oil must be registered with the Central Pollution Control Board (CPCB), and all used oil trades will be facilitated through a website monitored by the board[10]. Used oil would only be imported for re-refinement, and the government has implemented a mandate to achieve a 5% re-recycling target for year 1[11]. While the policy has not been enacted yet, successful implementation will leave one major issue regarding the process: a consistent, quality output of used oil. However, despite this issue, the scheme promises to enable consistent re-refined oil production, and successful scheme output for re-refined oils may become more consistent and more carefully regulated than before, raising the world's supply of sustainable oil and providing cleaner energy for India.

Finally, in 2023, Australia amended a long-standing policy that benefitted used oil recycling[13]. In 2001, the Australian government enacted an incentive system titled the Product Stewardship for Oil (PSO) scheme, aiming to "provide incentives to increase used oil recycling[13]." The PSO functioned with levies on the oil-based lubricants, with the used oil recyclers being paid benefits by the Australian Taxation Office (ATO) depending on the type of oil brought, as shown in Table 2[14]. With this scheme, oil recycling was encouraged, imported oil products were less necessary, and oil waste from improper disposal was significantly reduced.

While the act remains stable, an independent review of the operation of the act is required every 4 years[13]. The third independent review in 2014 prompted an increase in the levy rate to 8.5 cents per liter[13]. However, as was noted in the fourth independent review, this raise meant that the scheme was running at a deficit from 2015-2016 to 2019-2020, costing the government roughly $141.5 million in funding. In 2023, this levy increase was finally implemented.

As of July 1st, 2023, the Australian government officially raised the tariff on relevant goods from 8.5 cents per liter to 14.2 cents per liter, as noted in Category 8 of Table 2. While it appears to be a minor amendment to an existing act, the review affirmed that waste oil recycling was significantly improved, and an increase to the levy ensures that taxpayers will no longer have to pay extra for the service. If other incentives were implemented in developed systems, recycling could be further encouraged. The success of the PSO scheme indicates a probable blueprint to further incentivize used oil recycling. Thus, by implementing similar systems, used oil recycling could be streamlined and greatly improved, providing a tangible solution to the issue of used oil collection.

Figure 3: A diagram of the producer's responsibilities during a product's lifecycle under EPR[12].

Table 2: The PSO benefit rates for oil recycling as of July 1st, 2023[14].

Category	Benefit (Cents per Liter)
1. Re-refined base oil (for use as a lubricant or a hydraulic or transformer oil) that meets the specified criteria	50
2. Other re-refined base-oils (eg chain bar oil, oils incorporated into manufactured products)	10
5. High grade industrial burning oils (filtered, de-watered, and de-mineralised)	5
8. Gazetted oil consumed in Australia for a gazetted use	14.2

Conclusion

Overall, re-refined lubricants remain a strong alternative to standard oil. While the issue of collecting used oil remains a daunting task with no universal solution, several countries have demonstrated successful strategies in mitigating this issue. From tariffs and company-issued disposal equipment to policies requiring producers to assist in disposal and even an incentive-based scheme that rewards waste oil recycling, these governments have ingeniously crafted approaches that solve the issue while remaining easy to implement. With these approaches, re-refined oils can continue to develop without fear of supply issues. Inevitably, re-refined lubricants will become more plentiful and more reliable than conventional oils, and these global policies will remain at the forefront of that development.

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About the Authors

Dr. Raj Shah serves in the role of Director at Koehler Instrument Company in New York, boasting an impressive 28-year tenure with the organization. Recognized as a Fellow by eminent organizations such as IChemE, CMI, STLE, AIC, NLGI, INSTMC, Institute of Physics, The Energy Institute, and The Royal Society of Chemistry, he stands as a distinguished recipient of the ASTM Eagle award. Dr. Shah, a luminary in the field, recently coedited the highly acclaimed "Fuels and Lubricants Handbook," a bestseller that unravels industry insights. Explore the intricacies at ASTM's Long-Awaited Fuels and Lubricants Handbook 2nd Edition Now Available (https://bit.ly/3u2e6GY).

His academic journey includes a doctorate in Chemical Engineering from The Pennsylvania State University, complemented by the title of Fellow from The Chartered Management Institute, London. Dr. Shah holds the esteemed status of a Chartered Scientist with the Science Council, a Chartered Petroleum Engineer with the Energy Institute, and a Chartered Engineer with the Engineering Council, UK. Recently honored as "Eminent Engineer" by Tau Beta Pi, the largest engineering society in the USA, Dr. Shah serves on the Advisory Board of Directors at Farmingdale University (Mechanical Technology), Auburn University (Tribology), SUNY Farmingdale (Engineering Management), and the State University of NY, Stony Brook (Chemical Engineering/Material Science and Engineering).

In tandem with his role as an Adjunct Professor at the State University of New York, Stony Brook, in the Department of Material Science and Chemical Engineering, Dr. Shah's impact spans over three decades in the energy industry, with a prolific portfolio of over 625 publications. Dive deeper into Dr. Raj Shah's journey at https://bit.ly/3QvfaLX.

For further correspondence, reach out to Dr. Shah at rshah@koehlerinstrument.com.

Mr. Gavin Thomas and **Mr. Nicholas Douglas** are part of a thriving internship program at Koehler Instrument company in Holtsville, and are students of Chemical Engineering at Stony Brook University, Long Island, NY where Dr. Shah is the current chair of the external advisory board of directors.

Gavin Thomas

Nicholas Douglas

Author Contact Details

Dr. Raj Shah, Koehler Instrument Company • Holtsvile, NY11742 USA • Email: rshah@koehlerinstrument.com

• Web: www.koehlerinstrument.com