# Lubricant Consumption and Used Oil Generation in California: A Segmented Market Analysis

## Part I: California's Lubricant Consumption, 2000-2020

CalRecycle
California Department of Resources Recycling and Recovery

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# 1. FOREWORD

California's SB 546 mandates the conduct of the Used Oil Life-Cycle Assessment Project under the auspices of the Department of Resources Recycling and Recovery (CalRecycle). In part, the mandate is an effort to improve the understanding of opportunities to enhance the collection and recycling of used lubricating oils. "Lubricant Consumption and Used Oil Generation in California: A Segmented Market Analysis" offers valuable insights to all engaged in the ongoing analysis of the California lubricants market.

Detailed statistics on the consumption of lubricants at the state level are not available from public or proprietary sources. Crude estimates of state-level consumption by blenders are made in the U.S. Energy Information Administration's *SEDS* database, but these data are unreliable. CalRecycle's *Used Oil Recycling Rate Annual Reports* also provide summary figures on California's lubricants consumption, but these reports are widely believed to overstate industrial demand due to the data-gathering procedures employed. Moreover, no public data source segments state-level lubricants consumption in California beyond aggregated automotive and industrial end-use totals.

Kline maintains proprietary databases of annual lubricants consumption in the United States as a whole, containing detailed segmentation of national demand by the principal applications and end-use industries. Since no state-level data is available at this level of disaggregation, Kline has employed a "proxy" approach to estimating California's historical and projected share of national lubricants consumption. An allocation proxy uses a measure whose historical data is available at both the state and federal level, and which has a natural correlation with a particular lubricant end-use. For example, a proxy used for estimating California's sales of marine engine lubricants was its share of total U.S. sales of marine bunker fuels, as reported by the Energy Information Administration (EIA). Proxy measures examined in this study include, *inter alia*, demographic, economic, employment, transportation, and energy statistics and data. They are available from public and private sources that report data or statistics at both the national and state level. Careful attention was devoted to the selection of the most appropriate choices of allocation proxies, based on Kline's experience of lubricants uses in transportation and non-transportation applications. The proxy analysis was particularly critical in analyzing industrial lubricants consumption, due to the many economic sectors involved and the variety of process and non-process uses of lubricants.

This report describes the methodology, issues, and results of Kline's study. In addition, Kline's Excel-based **California Lubricants Consumption Model** is available to CalRecycle as a product of this study. It contains details of historical and projected annual consumption of lubricants at the national and California level covering the 2000-2020 time frame, divided into three primary segments: consumer automotive, commercial automotive, and industrial). Within those three segments further definition of lubricants consumption is provided, with the additional detail dictated by lubricant application and/or end use. Supporting data and statistics, used in the development of proxy measures, are also contained within the model.

Attached to this report is an Appendix detailing the principal nonproprietary sources that have been relied upon to provide data or insights in the preparation of this report, together with links to their respective websites.

# 2. INTRODUCTION

## 2.1. Overview

By most high-level macroeconomic and demographic measures, California is a significant contributor to national statistical totals. **Table 2-1** suggests that a simple proxy for California's share of national consumption, based on its broad-based economic activity, would be in the 12 to 13 percent range, based on 2010 data.

| **Table 2-1: California's Share of 2010 U.S. Measures** | |
|---|---|
| **Measure** | **CA % of U.S. Total** |
| Gross Domestic Product (GDP) | 13.0 |
| Personal Income | 12.9 |
| Vehicle Registrations | 12.8 |
| Population | 12.1 |
| *Sources: U.S. Census Bureau, BEA, DOT* | |

The overall character of the California economy is not dissimilar from that of the United States as a whole, with public- and private-sector services representing more than three-quarters of their respective GDPs. Manufacturing, which tends to be a key indicator of industrial lubricants use, also represents a similar proportion of GDP; in 2010 California's manufacturing GDP was 11.4 percent of total state GDP, compared with 11.8 percent for the United States as a whole.

## 2.2. Manufacturing Activity in California

It is only when manufacturing is disaggregated at the level of key industry segments (3-digit NAICS codes and beyond) that material differences in the composition of California's manufacturing, primary resource, and other energy-intensive industries (utilities, wholesale transportation, and construction) begin to emerge.

**Table 2-2** illustrates the relatively high concentration of California's manufacturing activity in two key industries: computer and electronics manufacturing, and petroleum and coal processing. All other manufacturing industries are proportionally under-represented in California vs. the United States as a whole.

It is axiomatic that, in California, the two industry segments with the highest proportional share of manufacturing GDP in the state (computers and electronics, and oil and coal processing) are those with well-below-average electrical intensity of their manufacturing GDP output.

The computer and electronics manufacturing industry in 2010 represented 30.3 percent of California's manufacturing GDP; however, due to its lack of heavy machinery, this industry segment has a relatively low intensity of heavy duty motive equipment requiring lubrication.

| Table 2-2: California's 2010 Manufacturing GDP Intensity Ratios vs. Total U.S. by Major Industry Segment | |
|---|---|
| **Manufacturing Industry** | **Ratio of CA % of Mfg. GDP to U.S. % of Mfg. GDP** |
| **Computers & Electronics** | **1.95** |
| **Petroleum & Coal Processing** | **1.69** |
| All Other Manufacturing | 0.84 |
| Chemicals | 0.71 |
| Plastics & Rubber | 0.54 |
| Machinery | 0.52 |
| Electrical | 0.51 |
| Primary Metals | 0.26 |
| Motor Vehicles | 0.21 |
| *Source: BEA* | |

A good indicator of the lubricant intensity of manufacturing is retail industrial electricity sales by NAICS code, published by the EIA in 2006. This data, illustrated in **Table 2-3**, shows the electrical intensity of U.S. industries (in terms of thousand KWh of purchased power per dollar of manufacturing GDP in that sector).

| Table 2-3: Electrical Intensity of 2006 U.S. Manufacturing GDP | | |
|---|---|---|
| **Manufacturing Industry Segment** | **KBtu/$ of Mfg. GDP** | **Ratio to Total Mfg.** |
| **Primary Metals** | **7.65** | **4.4** |
| **Non-metallic Minerals** | **3.25** | **1.9** |
| **Plastics & Rubber** | **2.79** | **1.6** |
| **Chemicals** | **2.50** | **1.4** |
| All Other Manufacturing | 1.97 | 1.1 |
| **Total Manufacturing** | **1.73** | **1.0** |
| Food & Beverage | 1.55 | 0.9 |
| Metal Fabrication | 1.14 | 0.7 |
| Motor Vehicles | 1.03 | 0.6 |
| Oil & Coal Processing | 0.98 | 0.6 |
| Electrical | 0.97 | 0.6 |
| Machinery | 0.96 | 0.6 |
| Computers & Electronics | 0.47 | 0.3 |
| *Sources: EIA, BEA* | | |

The primary metals production sector has a level of electrical intensity per dollar of manufacturing GDP, which is more than 16 times that of the computers and electronics manufacturing segment. This comparison may somewhat overstate the low electrical intensity of computer and electronic manufacturing due to the need for high-quality electric service reliability and corresponding deployment of captive primary or back-up self-generation.

To some degree, the low electrical-intensity of the oil refining industry may be caused by the significant amounts of internally generated and purchased gases that are burned for fuel and for on-site generation of electricity. Nonetheless, California's refining industry is important; as of Jan. 1, 2012, according to EIA data, it had 16 operating oil refineries out of a U.S. total of 134 (12.1 percent), and represented 10.8 percent of total operable crude capacity.

Conversely, industries with high levels of electricity use per dollar of output are under-represented in California. Primary metals production, with extensive use of heavy machinery such as rolling mills, is the most electricity-intensive manufacturing segment, but has a ratio of the California percentage of manufacturing GDP relative to the U.S. average of only 0.26. This is followed by non-metallic minerals, whose California-to-U.S. ratio of manufacturing GDP is 0.63.

In this study, Kline has recognized that it is important to analyze industrial non-process use of lubricants on an industry-by-industry basis, leading to a range of possible proxies for estimating California's share of each activity. As illustrated above, the use of general manufacturing proxies, such as GDP, tends to overstate significantly the levels of industrial lubricants use in California, since those industries that are heavy users of lubricants are under-represented in California and vice versa.

### 2.3. Process Industry Use of Lubricants in California

A second dimension of the analysis of prospective industrial use of lubricants in California is the sale of lubricating oil range materials for non-lubricating uses, where the lubricant is employed in the manufacturing process because of its stability, chemical composition, dielectric properties, liquidity range, etc. These non-lubricating uses encompass process oils, metalworking fluids, hydraulic fluids, and a variety of other more specialized applications. Process oils are the most significant of these non-lubricating end-use categories, representing nearly 45 percent of U.S. industrial lubricants use in 2010 (**Table 2-4**).

**Table 2-4: U.S. Industrial Lubricants Consumption by Application**

| Industrial Application | 2010 Consumption (Million Gallons) | % of Total |
|---|---|---|
| Process Oils | 562.9 | 44 |
| Hydraulic Fluids | 180.6 | 14 |
| Metalworking Fluids | 150.4 | 12 |
| Industrial Lubrication | 372.8 | 30 |
| **Total Industry** | **1,266.7** | **100%** |
| *Source: Kline* | | |

Process oils are used primarily in the rubber, chemicals, electrical, food processing, and printing ink industries, as illustrated in **Table 2-5**. Of these, process oils used in the rubber industry are by far the most significant in volumetric terms. About 70 percent of rubber industry use of process oils is concentrated in tire manufacturing, an industry that has essentially abandoned California. A Firestone tire manufacturing plant in Salinas was closed in 1980, followed by

Pirelli's Hanford facility in 2001. At this point, the only active tire-related production facility in California is Bridgestone's tread rubber and retreading plant in Long Beach. Indicators of manufacturing activity associated with tire manufacturing, obtained from the 2007 Economic Census, show low levels of employment activity (about 0.2 percent of national employment after the 2002 Census) in this industry segment (NAICS: 326211) in California.

**Table 2-5: U.S. Process Oil Consumption by Application and Industry**

| Process Oil Type | 2010 Consumption (Million Galls) | Key Industries Served |
|---|---|---|
| Rubber Oils | 204.6 | Tires, Rubber |
| White Oils | 89.9 | Chemicals, Food |
| Electrical Oils | 82.5 | Transformers |
| Printing Inks | 77.8 | Printing |
| All Other | 108.1 | Chemicals, Agriculture |
| **Total** | **562.9** | |

*Source: Kline*

A second important use of process oils is in the electrical oils category, where almost 90 percent of oils are used for transmission (step-up) and distribution (step-down) transformer oils. Though it is not possible to determine state-level GDP at the six-digit NAICS code representing transformer manufacturing (335311), the five-year Economic Census provides indicators of the numbers of establishments and employment at the state level. Thus, the most recent (2007) manufacturing census data shows 6.8 percent of U.S. employees in NAICS code 335311 were located in California. This statistic corresponds reasonably with another indicator of transformer manufacturing activity: new housing starts. California's share of this measure has ranged from 6.6 percent to 10.9 percent between 2000 and 2010.

# 3. PROXY OPTIONS FOR ESTIMATING CALIFORNIA LUBRICANTS CONSUMPTION

## 3.1. Introduction

Since primary data on California's historical consumption of lubricants is unavailable, and reservations exist concerning the reliability of at least certain components of state consumption reported by CalRecycle, an independent approach was developed by Kline to simulate past and expected future demand. As previously noted, historical proxies are based on published statistics that are available at both the state and national level and that have a fundamental causative connection with the particular end-use of lubricants being analyzed. If there was a substantive degree of statistical fit between the proxy choice and reported segment consumption of lubricants at the national level, that analysis reinforced our choice. However, we were disinclined to choose proxies with higher correlation coefficients if they failed to have a logical connection with the lubricant end-use being analyzed.

A second criterion employed in proxy choices was that the measure was available on an annual basis beginning 2000, and preferably extending through 2011. Oil and gas consumption data is available at the national and state level through 2011 through the Energy Information Administration (EIA). Other measures of energy consumption are generally published by EIA through 2010, though industrial consumption of electricity by industry is published only for 2006. Most statistics addressing economic and transportation activity are sourced through 2010 through the Commerce Department's Bureau of Economic Analysis (BEA) and the Department of Transportation (DOT) Federal Highway Administration's RITA database, respectively. However, 5- and 6-digit NAICS code data on state-level establishments, employment, and sales are available only from the U.S. Census Bureau's Economic Census at five-year intervals (1997, 2002, and 2007; the 2012 edition will not be published until 2013).

## 3.2. Manufacturing Industry Proxies

Manufacturing industry statistics reporting economic activity for detailed industry sub-segments (5- and 6-digit NAICS Codes) do not provide state-level GDP data. In this case, Kline used the Census Bureau's Economic Census databases which report, among others, employment and number of establishments at the state and national level. The Economic Census data is, however, available only at five-year intervals; thus Kline relied upon detailed 5- and 6-digit NAICS economic data from the 1997, 2002, and 2007 Economic Census surveys for data related to certain industries in which lubricants consumption was believed to vary significantly between different segments of a 3- or 4-digit NAICS code. For example, in the rubber and chemical manufacturing industry (NAICS Code 326), an overall proxy is inaccurate since specific consumption of process and non-process lubricants is much higher in certain stages of rubber industry activity (notably tire manufacturing) than it is in chemicals production.

Unlike the automotive sector, where the proxies available for simulating California's share of light duty and heavy duty vehicle lubricant applications are generally fairly closely related, this is not the case with industrial applications (Table 3-1). As previously noted, the computer and electronics manufacturing industries are heavily concentrated in California, representing almost one-quarter of U.S. output in this sector.

| Table 3-1: Proxy Measures Indicative of California's Industrial Lubricants Consumption | | | |
|---|---|---|---|
| **Source** | **Proxy** | **Year** | **CA % of U.S.** |
| BEA | Manufacturing GDP - Computer & Electronics | 2010 | 24.8 |
| BEA | Manufacturing GDP - Petroleum & Coal Processing | 2010 | 21.3 |
| EIA | Marine Bunker Fuel Sales/Deliveries | 2010 | 20.6 |
| BEA | GDP | 2010 | 13.0 |
| BEA | Personal Income | 2010 | 12.9 |
| BEA | Manufacturing GDP | 2010 | 12.6 |
| EIA | Railroad Use of Distillate Fuel | 2010 | 12.1 |
| BEA | Non-durable Goods Manufacturing GDP | 2010 | 11.7 |
| EIA | Operable Refinery Capacity | 2010 | 11.1 |
| BEA | Manufacturing GDP - Food and Beverages | 2010 | 10.0 |
| **CalRecycle** | **Industrial Lubricants Consumption, excl. Dielectrics** | **2010** | **9.4** |
| BEA | Manufacturing GDP - Chemicals | 2010 | 9.0 |
| EIA/SEDS | Total Energy Consumption | 2010 | 8.2 |
| AGA | Miles of Natural Gas Pipelines - All Types | 2010 | 7.6 |
| EIA | Farm Use of Distillate Fuels | 2010 | 7.3 |
| EIA | Retail Electricity Consumption | 2010 | 6.9 |
| BEA | Manufacturing GDP - Plastics & Rubber | 2010 | 6.8 |
| EIA | Electric Generating Capacity | 2010 | 6.4 |
| Cal ISO/EIA | Electric System Peak Load | 2010 | 6.2 |
| EIA/SEDS | Industrial Energy Consumption | 2010 | 6.0 |
| EIA/SEDS | Industrial Electricity Consumption | 2010 | 5.1 |
| BEA | Manufacturing GDP - Paper | 2010 | 5.1 |
| EIA | Gas Pipeline and Distribution Use | 2010 | 1.4 |
| Census Bureau | Employment in Tire Manufacturing | 2007 | 0.2 |

Manufacturing GDP data show more than one-fifth of U.S. output in the oil and coal processing segment is located in California, though this heavy concentration is inconsistent with the fact that only 11.1 percent of U.S. operable refinery capacity is located in-state. Equally, the California Energy Commission’s Weekly Fuels Watch Report shows state crude oil input to refineries as 1.61 million barrels per day in 2011, which is 10.5 percent of U.S. crude runs in that year. As a result of this anomaly, Kline discarded manufacturing GDP in oil and other fossil fuel processing as a viable proxy measure.

A third measure of industrial activity which is notable for its proportional over-representation in California is sales of marine bunker fuels, consisting of heavy fuel oil (Bunker C or No.6 Oil, and No.5 Fuel or Navy Special), marine diesel (No.4 fuel) and marine gas oil (No.2 fuel). Marine bunkers are sold at commercial ports, primarily at Los Angeles/Long Beach and Bay Area ports. According to Census Bureau data for 2011, California ports combined accounted for

12 percent of international waterborne shipments by tonnage, with Los Angeles/Long Beach accounting for nearly three-quarters of California trade (Long Beach and Los Angeles harbors ranked fifth and ninth, respectively, in 2010 rankings of U.S. ports in terms of cargo shipped). Only 2 percent of international waterborne trade in California is conducted outside the Los Angeles/Long Beach and Bay Area ports, primarily through San Diego. In addition to international commercial trade, California has a significant interstate marine trade in Jones Act (U.S. flag) shipping of materials, a particularly notable example being tanker movements of Alaskan crude oil to Californian refineries (though volumes are declining they are still significant). Due to California's extensive coastline, there is also significant intrastate cabotage, principally between the Los Angeles/Long Beach and Bay Area ports and vice versa. Finally, naval bases are located in Southern California, with San Diego as the home port for the Navy's Pacific Fleet. All of the above marine activity, the heavy API gravity of California's crude oil slate to refineries resulting in excess fuel oil, and the virtually nonexistent in-state demand for residual fuel oil make the California coast a key location worldwide in marine bunkering activity. In 2010, EIA statistics show that 99.9 percent of residual fuel oil sold in California was directed to the bunker fuel market. Marine lubricants are closely associated with that trade since common practice is for vessels to top up with marine engine and gear lubricants at every bunker fueling stop where these materials are available under their worldwide bunkering contracts.

Among the proxies that are disproportionately under-represented in California, the tire and rubber industry has already been singled out. However, another example is the case of natural gas compressors or gas engines used in the interstate and intrastate gas transmission industry. Though California is a major natural gas consumer, representing 10.3 percent of U.S. natural gas volumes delivered to consumers in 2010, typically only 10 to 13 percent of the state's consumption of natural gas is sourced from in-state wells. As a result, five major interstate natural gas transmission pipelines supply California, from out of state, with the remaining plus or minus 90 percent of its gas demand, which cannot be met from local sources. The major interstate gas pipelines (Gas Transmission Northwest, Kern River, Transwestern, El Paso, and Mojave) serving California originate in several North American gas-producing regions, including the Rocky Mountain, San Juan, and Anadarko Basins of the western and southwestern United States, as well as those in Alberta and British Columbia in Western Canada. The compression station capacity on these systems, which is required to deliver gas at high pressure into Californian markets, is located principally outside the state. This tends to explain the low incidence of natural gas fuel used for pipeline and distribution use (only 1.4 percent of U.S. consumption in this category in 2010).

A final noteworthy industrial proxy is the consumption of electricity by industry. In modeling lubricants consumption by the key industrial applications, we have attempted to rely on proxies that best simulate the uses of lubricants in process and non-process applications. Process oils, with the exception of electrical oils, are largely or totally consumed in the manufacturing activity with which they are associated. In certain metalworking fluid applications, the lubricant functions primarily as a heat sink or quenching agent.

The traditional non-process uses of lubricants in industry are associated with friction reduction in motive equipment or in the hydraulic transmission of power in industrial machinery. In both cases the equipment and machinery is largely driven by electricity. Certain industries, including pulp and paper, refining, and chemicals, are major users of auto-generated steam, but this steam production is employed mainly in process applications. Across the United States about 35 percent of total non-process energy used in industrial applications is sourced from self-generation. While these same process industries, notably pulp/paper and oil refining, are significant self-generators of electricity, all manufacturing industries rely on purchased power, with few exceptions. In most cases, other than the above examples, self-generation is limited to power quality control or emergency backup. As a result, Kline has elected to use industrial consumption of electricity as a relevant proxy in applications in which lubricants are used principally for friction control in rotating equipment and other moving parts (general industrial oils and greases), as well as in certain applications for power transmission (such as select hydraulic fluids).

### 3.3. Automotive Industry Proxies

Kline's databases of automotive consumption of lubricants, covering engine oils, transmission fluids, gear oils, and greases, are subdivided into two principal categories:

- **Consumer automotive oils**, which are used in automobiles, SUVs, and other light-duty trucks, collectively referred to as light-duty vehicles (LDVs), as well as those employed in light-duty off-road applications (such as recreational boats, ATVs, and other consumer off-road vehicles, and lawn and garden use).
- **Commercial automotive oils**, which are used in heavy duty on-road trucks and other on-road vehicles not classified as LDVs. Off-road heavy-duty uses of motive engine oils, such as in railroad engines, farm equipment, ocean-going vessels, and other off-road heavy machinery, are included in Kline's definition of industrial oils. This definition differs from that used by CalRecycle—a topic that will be discussed in Chapter 6 of this report.

#### 3.3.1. Light Duty Vehicles

The principal distinction between the consumer and commercial categories is that consumer uses in the United States are linked almost exclusively to lubricating the engines and drivetrains of gasoline-fueled (and more recently E10, which contains up to 10 percent ethanol by volume) internal combustion engines. While a temporary surge in U.S. diesel-engine vehicle sales occurred in the mid-1970s in response to the first oil crisis, the added fuel and vehicle cost, and emissions, of previous generations of retail automotive diesel engines has been their undoing in the United States, where on-road diesel use is not subsidized. According to the American Petroleum Institute, the current (September 2012) U.S. average total of federal and state taxes levied on gasoline is 48.9 cents/gallon, while on-road ULSD taxes are actually higher, at 53.8 cents/gallon.

In Europe, conversely, about 50 percent of the vehicle fleet is diesel-powered, due to the high cost of transport fuels and the development of high-efficiency (30 percent greater mpg), lower-emissions diesel engines, led by the German auto industry. German consumers in particular are encouraged by a differential tax structure that currently imposes almost $1/gallon higher taxes on gasoline than on diesel for automotive use. In the past several years there has been a modest recovery in U.S. sales of German advanced diesel-engine passenger cars, which totaled 77,877 vehicles in 2010; however, that increased volume represented only 0.7 percent of total U.S. light duty vehicle sales in that year, according to NADA/R.L. Polk data. The U.S. population of Alternative Fuel Vehicles (including hybrid FFVs designed to run primarily on E85), electric vehicles, gas-fueled vehicles (LNG, CNG, and propane), and other non-gasoline-powered light-duty vehicles also remains a very minor proportion (826,000 in 2009) of the light-duty vehicle fleet, which totaled 240.6 million vehicles as of 2011, according to NADA statistics.

Since gasoline use is strongly linked to the light duty vehicle population, it is a clear choice as a proxy for consumer automotive lubricant use in engine oil and related applications. **Table 3-2** provides a long list of potential proxies for LTV use, also including those which are more relevant to heavy duty track use, which is discussed in 3.3.2 below. Thus, California's share of U.S. gasoline consumption should provide a reliable proxy for most consumer automotive uses, since driver behaviors in terms of miles driven per year, and oil change frequency, are not expected to be discernibly different from those of the United States as a whole.

**Table 3-2: Proxy Measures Indicative of California's Automotive Lubricants Consumption**

| Source | Proxy | Year | CA % of U.S. |
|---|---|---|---|
| DOT/FHA | Automobiles | 2010 | 13.7 |
| DOT/FHA | Light Duty Vehicle Registrations | 2010 | 13.2 |
| DOT/FHA | All Motor Vehicle Registrations | 2010 | 12.8 |
| DOT/FHA | Licensed Drivers | 2009 | 11.3 |
| EIA | Gasoline/Prime Supplier Volumes | 2010 | 11.2 |
| EIA/SEDS | Gasoline/Consumption | 2010 | 10.9 |
| DOT/FHA | Vehicle-Miles Driven | 2010 | 10.9 |
| Census Bureau | Single Family Detached Homes | 2010 | 9.8 |
| **CalRecycle** | **ICE-related Lubricants Consumption** | **2010** | **9.7** |
| DOT/FHA | Motorcycle Registrations | 2009 | 9.6 |
| BLS | For-hire Trucking Employment | 2009 | 8.0 |
| EIA | On Road Diesel/Prime Supplier Volumes | 2010 | 7.2 |
| DOT/FHA | Truck-tractor Registrations | 2008 | 6.8 |
| EIA/SEDS | Distillate/Consumption | 2010 | 6.7 |
| MCSA | Motor Carrier Establishments | 2008 | 6.6 |
| US Coastguard | Boat Registrations | 2010 | 6.5 |
| CPSC | ATV Deaths | Cumulative | 5.0 |
| ISMA | Snowmobile Registrations | 2010 | 1.4 |

While reported data on oil change intervals at the roughly 16,000 Do-it-for-Me (DIFM) outlets such as Walmart, Firestone, and Jiffy Lube shows a nominal increase (from 4,400 miles in 2000, to 4,630 miles in 2011), it is believed that the frequency of oil changes by the non-DIFM sector (which Kline estimates to have averaged roughly 5,000 miles in 2000) has decreased considerably.

This latter trend is driven in part by the original equipment manufacturers, or OEMs (whose oil change interval recommendations have increased), to the increasing use of oil monitors, and to the general state of the economy where drivers are postponing marginal maintenance expenses, if possible. Oil change interval data is not available at the state level from any source, and only national-level data is published for the responding membership in the DIFM industry's "*Fast Lube Operators Survey.*"

A secondary distinction was made in the segmentation of consumer-related consumption of lubricant proxies. Kline estimates that about 4 percent of U.S. gasoline demand is consumed in a wide variety of non-LDV (light duty vehicle), non-farm applications. These niche residential and light commercial sectors use two- and four-stroke gasoline engines almost exclusively. They include off-road vehicle uses (such as ATVs and utility and golf carts), lawn and garden equipment (particularly lawnmowers), and recreational boats.

It is important to an understanding of these non-LDV uses to estimate in broad terms the population and relative fuel consumption of these varied types of gasoline engines (see **Table 3-3**), as well as the nature of the combustion cycle (two- or four-stroke). Lawnmowers, of which ride-on tractors for commercial and residential use comprise some 10 million units, are the largest consumers of gasoline in non-LDV, non-farm applications. All modern gasoline-powered lawnmower engines are four-stroke, which implies that used sump oil is recoverable when the engine oil is changed. While certain brands of engine oil are specifically designed for off-road non-LDV use, Kline believes that the bulk of engine oils used in lawnmowers are multi-grade passenger car motor oil (PCMO).

**Table 3-3: U.S. Gasoline Use in Non-Automotive Applications in 2010**

| End-Use | Number of Units* (Million) | % 2-Stroke of Total | Gasoline Consumed (% of Total) |
|---|---|---|---|
| Lawnmowers | 55.3 | 0% | 1.5% |
| Other Lawn & Garden Equipment | 83.0 | 90% | 0.5% |
| Recreational Boats | 11.6 | 27% | 1.1% |
| Off-road Vehicles | 9.7 | 19% | 0.4% |
| Motorcycles & Dirt Bikes | 11.3 | 8% | 0.4% |
| **Total** | **170.9** | **47%** | **3.9%** |

* Gasoline-powered engines only; excludes diesel and electric units

*Source: Kline estimates*

Other lawn and garden equipment such as chainsaws, leaf blowers and trimmers, and snowblowers, are predominantly two-stroke today, on account of their portability. There is a slow trend toward the introduction of more four-stroke engines, but this is likely to be insignificant in the context of the California market scale.

Recreational boats, including outboard, inboard/outboard, stern-drive, and PWC jet-drive engines, are powered almost exclusively by gasoline engines. Two-stroke engines exist only in the outboard category; currently some 35 percent of outboard engines are two-strokes, and this percentage is diminishing as outboard motor horsepower increases.

Off-road vehicles include a wide variety of recreational, residential, and commercial vehicles, including ATVs, snowmobiles, dune buggies, go-carts, golf carts, and utility vehicles. Of the estimated 10.9 million vehicles in operation in 2010 in this category, 6.0 million were ATVs. Electric motors are found only in golf and utility carts and account for a little more than 1 million units in total. On-road motorcycles (8.2 million units) and off-road dirt bikes (3.1 million units) are the final category of non-LDV equipment use. All on-road motorcycles are now four-stroke, but some 30 percent of the dirt-bike population has two-stroke engines, on account of their greater portability.

Though two-stroke engines represent nearly half of the estimated 170.9 million gasoline-powered units in service in 2010, their aggregate fuel consumption is lower, due to the predominant use of two-stroke engines in lawn and garden equipment where engine capacity and horsepower output are low. As a result, these two-stroke engines in aggregate used less than a quarter of the gasoline consumed by all non-LDV units.

### 3.3.2. Heavy Duty Vehicles

In Kline's segmentation of lubricants sales and consumption, commercial automotive applications are defined as those arising out of on-road and off-road mobile vehicle transportation involving all vehicles classified by the FHA outside the light-duty classification. This group consists of a variety of different heavy-duty-powered vehicles including Class 3-8 truck-tractors, straight trucks of various designs, buses, and specialty commercial equipment. These vehicles are owned and operated by individuals, for-hire carriers, and public- and private-sector fleet operators. Our designation also includes off-road vehicles used for heavy duty commercial purposes, predominantly in the agricultural, construction, and mining segments of the economy (see **Table 3-4**).

**Table 3-4: U.S. Heavy Duty Vehicle Fleet in 2010**

| Vehicle Type | Number of Units (Million) | Est. Diesel % of Total |
|---|---|---|
| Farm Tractors | 4.8 | 80% |
| Trucks, 2-axle, 6+ Tires | 8.2 | 75% |
| Truck-Tractors | 2.6 | 100% |
| Buses | 0.8 | 90% |
| Other Off-Road Vehicles | 0.5 | 95% |
| **Total** | **16.9** | **81%** |

*Sources: DOT/FHA, Kline estimates*

**Table 3-4** illustrates the reported distribution of on- and off-road heavy-duty vehicles in 2010, as well as an estimate of the approximate proportion of the fleet that is diesel-fueled. While diesel is the dominant fuel in this vehicle class, gasoline is also used in smaller farm tractors, lower GWV Class 3 and 4 two-axle trucks, and medium-duty off-road vehicles. Other fuels used in buses include CNG, LNG, and a variety of biofuels.

In the on-road category, data is unavailable regarding the proportions of fuel use by engine and vehicle type, though the DOT's Bureau of Transportation Statistics provides a breakdown of combined gasoline and diesel consumption by on-road vehicles; the latest year of data provided is for 2008 (**Table 3-5**). This data shows that consumption by truck-tractors, which are 100 percent fueled by diesel, are the largest segment of on-road, non-LDV fuel demand.

**Table 3-5: U.S. Fuel Consumption by Vehicle Type in 2008**

| Vehicle Type | Gasoline and Diesel (Billion Gallons) | % of Total |
|---|---|---|
| Light Duty Cars & Trucks | 121.0 | 68% |
| Trucks, 2-axle, 6+ tires | 17.1 | 10% |
| Trucks-tractors | 30.6 | 17% |
| Buses | 2.1 | 1% |
| Farm Tractors | 4.3 | 2% |
| Other Off-road Vehicles | 2.2 | 1% |
| **Total** | **177.3** | **100%** |

*Sources: BTS, DOE/EIA, Kline*

Data on off-road fuel consumption by vehicle type is difficult to obtain and has been estimated by Kline, with assistance from EIA's Distillate Fuel Oil Sales by end-use statistics.

In conclusion, all evidence points to the large preponderance of diesel-fueled vehicles among the population of heavy duty on- and off-road vehicles. Because of the high utilization of the truck and bus fleet relative to off-road vehicles, diesel consumption (as opposed to vehicle count) is considered to be a more accurate indicator of relative activity and, as such, a more appropriate proxy for estimating California's share of U.S. commercial lubricants consumption.

## 4. DATA SOURCES

In order to develop proxy-driven estimates of past and projected Californian lubricants consumption, several key Kline proprietary sources were used:

- Kline's proprietary *Lubesnet* database, which details U.S. historical lubricants consumption by application and end-use in great detail from 2004 onward, and in somewhat lesser detail previously; it also projects U.S. consumption by key application to 2020. The database and forward projections are updated annually, based on a combination of primary research and materials provided by participants in the lubricants value chain.
- Kline's occasional series of proprietary *Opportunities in Lubricants* multi-client subscription reports, covering U.S. lubricants consumption and key drivers of demand at detailed levels of segmentation, including geographic breakdowns by the Petroleum Administration for Defense Districts; these reports are produced for consumer and commercial automotive motor oils and ancillary fluids, and for industrial oils approximately every three to five years.
- Selected data from Kline's confidential files and proprietary studies.

These sources provided the entire basis for collecting information on total U.S. finished lubricants consumption for the historical time period from 2000 to 2011, and for projecting this demand to 2020.

Two sources were employed for development of statistics on past California lubricants consumption for comparison with Kline's estimates of state-level demand, though we recognize there are deficiencies in both sets of data:

- CalRecycle's *Used Oil Recycling Rate Annual Reports*, which detail California's annual consumption of lubricants and industrial oils. As discussed in other sections of this report, there are material differences between Kline's and CalRecycle's segmentation and definitions, with the result that total and segment consumption figures differ. In addition, it is widely held that CalRecycle's industrial lubricant consumption figures are significantly overstated due to duplication in reporting procedures.
- The Energy Information Administration's (EIA) *State Energy Data System (SEDS)* database, which lists historical consumption of lubricants by state and year. There are two primary concerns with this data. First, EIA uses constant percentages of national demand for each state's automotive and industrial consumption over time, though the percentages are different for the two groups of lubricants (9.9 percent for automotive use, and 7.0 percent for industrial use). Second, it is believed that EIA reports only base stock volumes supplied to blenders and does not account for the additional volumes of additives and associated diluent oils, which are required to produce finished lubricants. Kline has adjusted EIA's figures for typical blending ratios of additive packages in automotive and industrial use, in a comparison of Kline's estimates of California lubricants consumption with other sources, in Chapter 6.

In the process of developing data that was available at both the state and federal levels for possible use as allocation proxies, a wide variety of public sources was consulted. The principal public agencies upon whose databases and reports Kline relied included, in particular:

- The U.S. Department of Energy's Energy Information Administration, whose website, and associated *State Energy Data System (SEDS,)* provides a wealth of detailed statistical information at both the national and state levels on petroleum products, natural gas, electricity, and other energy consumption, frequently by a variety of end-uses
- The U.S. Department of Commerce's Bureau of Economic Analysis, which reports on the details of economic accounts, including GDP and other macroeconomic data, nationally to the level of 5- and 6-digit NAICS codes, and for individual states generally at the 3-digit NAICS level
- The U.S. Census Bureau's annual demographic statistics database, together with its five-year Economic Census, which reports on details of establishments, employees, and sales by state down to the level of 5- and 6-digit NAICS codes
- The U.S. Department of Transportation's Bureau of Transportation Statistics, whose RITA databases provide information on the characteristics of the U.S. on-road, commercial marine, locomotive, and farm vehicle fleets, in terms of population by vehicle class, annual mileage driven by vehicle class, and other salient data. In some, but not all, cases this data was available at the state level.
- The U.S. Coast Guard, whose annual Recreational Boating Statistics report provides information on the population of pleasure boats by state, by form of propulsion, and other measures

The final group of public sources consulted by Kline consisted of databases or annual reports published by a host of industry associations including but not limited to:

- The National Automobile Dealers Association (NADA)
- The American Petroleum Institute (API)
- The American Gas Association (AGA)
- The National Electrical Manufacturers Association (NEMA)
- The National Home Builders Association (NAHB); state-level data on new housing starts was sourced from the California Builders Industry Association (CBIA)

# 5. CALIFORNIA LUBRICANTS CONSUMPTION PROXY CHOICES

## 5.1. Automotive Lubricants Classification

The automotive lubricants market is segmented by Kline into two major classes, with several key products segments contained within those classes. It is Kline's convention to split the overall automotive lubricants market into consumer and commercial (heavy-duty) segments. The consumer automotive segment includes all engine oils and associated fluids that are used in the operation and maintenance of passenger cars, light duty trucks and gasoline-using light duty off-road vehicles and equipment. The main lubricant products used in this category are passenger car motor oil (PCMO), engine oil for consumer and light duty commercial off-road vehicles and equipment (such as boats, ATVs, and lawn and garden equipment), automatic transmission fluid (ATF), consumer gear oil, and consumer grease.

The commercial automotive segment includes all lubricants consumed by on- and off-highway heavy duty vehicles. These vehicle applications include on-road trucks within Class 3 and above (both two-axle vehicles with six or more tires, and truck-tractors), buses, off-road construction and excavation equipment (such as earth movers and bucket loaders), and motorized agricultural equipment including tractors, combine harvesters, etc. The lubricant products consumed within these applications are heavy-duty motor oil (HDMO), hydraulic and transmission fluid (HTF), commercial gear oil, and commercial grease. Moreover, with respect to HTF, this category includes hydraulic transmission fluid, power take-off fluid, automatic transmission fluids (the use of which has recently started to increase in commercial applications), and finally hydraulic fluid used in the hydraulic actuator arms of, for example, bucket loaders and earth movers.

## 5.2. Proxy Choices for Consumer Automotive Lubricants Consumption

The consumer automotive sector captures engine oils and other fluids supplied to light-duty (Class 1 and 2) vehicles in the U.S. fleet, consisting of automobiles, SUVs, and light-duty trucks and pickups. Also accounted for in the consumer category is lubricating oil supplied to classes of on- and off-road vehicles and equipment generally associated with consumer use, such as motorcycles, recreational boats, ATVs, snowmobiles, golf carts, and lawn and garden equipment. This latter group has been separately identified because of the significant use of two-stroke engines among several vehicle types, notably outboard motors, ATVs, and snowmobiles; two-stroke engines are also dominant in portable non-lawnmower lawn and garden equipment, such as chain saws, leaf blowers, and trimmers.

As previously discussed in Chapter 3, gasoline (or more precisely E10) is the sole or dominant fuel choice among all the above U.S. consumer-related uses, with only one exception. Electric carts used in the golf industry now outnumber gasoline-powered cars by a ratio of about 1.3:1; however, gasoline-powered golf carts and utility vehicles employed outside golf course duty outnumber their electric-powered brethren. In the overall scheme of consumer-related activity, gasoline powered-vehicles and equipment account for more than 98 percent of all fuels supplied to the consumer and related vehicle and equipment market.

As a result of the dominant use of gasoline in vehicles and equipment used in the consumer category, total gasoline consumption was selected as the preferred proxy for automotive engine oils and associated fluids, such as automatic transmission fluids (ATF), gear oils, and greases. Since no measurable differences exist between driving habits in California and those of other states, the state's proportional gasoline consumption as a percentage of total U.S. consumption is the preferred indicator of driving activity and hence engine oil consumption, since the vast majority (about 95 percent) of consumer engine oil consumption is associated with oil changes as opposed to initial fill and top-up volumes. While oil change intervals in the DIFM and DIY markets are increasing, no evidence is available to suggest any disproportionate behavior among California's drivers. Accordingly, the proxy selected for on-road vehicle engine oils, ATF, gear oils and greases was EIA's *Prime Supplier Sales Volumes* reports for all Motor Gasoline volumes. Using this proxy measure, California's share of total U.S. gasoline consumption ranged from 10.9 percent to 11.7 percent during the 2000 to 2011 period, with an average of 11.3 percent.

The only group of consumer engine oils and associated fluids whose estimated California consumption was not driven directly by the gasoline consumption proxy were the motorcycles, off-road vehicles, and equipment previously mentioned. In most cases, the use of engine oil is more linked to engine-hours than it is to miles driven. Since engine-hours are either not measured or not noted in many of these applications, and the population of several groups is known only approximately, a different approach was used in estimating California's proportional consumption of gasoline in these uses. Kline started by developing estimates of the vehicle or unit counts among the key groups of gasoline engine-driven applications (**Table 5-1**). In certain cases, such as on-road motorcycles and recreational boats, registration data was available, from the DOT/FHA and U.S. Coast Guard respectively. All other off-road equipment except snowmobiles (whose registration data was obtained from the International Snowmobile Manufacturers Association) is not registered. Estimates of their population were made by Kline, relying on press reports and industry articles. In addition, Kline estimated the percent of each equipment type that was driven by 2- or 4-stroke engines, as well as the approximate volume of gasoline consumed by each category of equipment in 2010, based on estimated average engine-hours/year and specific gasoline consumption by unit-hour.

**Table 5-1: U.S. Non-Automotive Consumer Equipment and Gasoline Consumption in 2010**

| Equipment Type | Number of Units (Million) | 2-stroke Units (% of Total) | Gasoline Consumption (Billion Gallons) |
|---|---|---|---|
| On- & Off-Road Motorcycles | 11.3 | 8% | 0.49 |
| Recreational Boats | 11.6 | 27% | 1.44 |
| ATVs & Other Off-Road Vehicles | 8.3 | 19% | 0.39 |
| Snowmobiles | 1.4 | 93% | 0.15 |
| Lawnmowers | 55.3 | 0% | 2.01 |
| Other Lawn & Garden Equipment | 83.0 | 90% | 0.67 |
| **Total** | **170.9** | **48%** | **5.15** |

*Source: Kline estimates*

Kline then applied proxies of the estimated percentage of units in California, based on direct or related measures, since proxies are unavailable directly for certain applications. Thus data on the 2010 percentage of U.S. registrations in California was used for motorcycles, recreational boats and snowmobiles. In all other cases direct proxies were unavailable. In these cases Kline applied other indicators that were believed to be relevant:

- ATV deaths in CA as a percent of total cumulative deaths in the United States as a whole. Taking ATV death statistics for California and comparing them to the ATV death rates for the United States, we are able to estimate ATV use in California based on ATV use in the United States.
- Single family homes in California, as a percent of total U.S. numbers, as an indirect proxy for the relative number of lawns and, hence, lawnmowers and other garden equipment.

These proxy percentages were applied to the total U.S. gasoline consumption in 2010, shown in **Table 5-1**, and distributed between 2-stroke and 4-stroke applications according to the unit proportions, also shown in Table 5-1. This data then lead to the development of the volumes of gasoline consumed in California in each application by engine type (**Table 5-2**). The California volumes were then divided by the U.S. volumes to determine a proxy percentage for 2-T and 4-T applications. Table 5-2 shows that the estimated aggregate California proxy percentages, based on proportional gasoline consumption, are 8.5 percent for four-stroke engine applications, and 7.6 percent for two-stroke engine applications.

**Table 5-2: CA Share of U.S. Non-LDV Gasoline Consumption by 2- and 4-Stroke Engines**

| **Equipment Type** | **Proxy** | **CA % of U.S.** | **CA Gasoline Use (Million Gals)** | |
|---|---|---|---|---|
| | | | **2-T** | **4-T** |
| On- & Off-Road Motorcycles | Registrations | 9.3% | 4 | 42 |
| Recreational Boats | Registrations | 6.5% | 25 | 69 |
| ATVs & Other Off-Road | ATV Deaths | 5.0% | 4 | 16 |
| Snowmobiles | Registrations | 1.4% | 2 | 0 |
| Lawnmowers | Single Family Homes | 9.8% | 0 | 197 |
| Other Lawn & Garden Equipment | Single Family Homes | 9.8% | 58 | 8 |
| TOTAL CA GASOLINE CONSUMED (Million Gals) | | | 93 | 332 |
| TOTAL U.S. GASOLINE CONSUMED (Million Gals) | | | 1,230 | 3,920 |
| **2-T and 4-T % of Total U.S. Off-Road Consumption** | | | **24%** | **76%** |
| **CA % of Total U.S. Off-Road Consumption** | | | **7.6%** | **8.5%** |
| *Source: Kline estimates* | | | | |

In the California lubricants consumption model, the above proxy percentages were applied to the estimated U.S. volumes of 2- and 4-T engine oils used in each non-automotive category. These volumes differ from, and are higher than, those recorded in Kline's *Lubesnet* database. This anomaly arises from the fact that *Lubesnet* estimates the volumes of purpose-branded lubricants sold in these segments rather than their actual use (which was derived from a recent Kline proprietary study). The implication is that significant quantities of branded multi-grade automotive engine oil are used in off-road vehicles and lawn and garden equipment. Accordingly, we adjusted the total U.S. volumes of multi-grade PCMO sold in light-duty vehicles downward by the estimated amounts of such lubricants that were diverted to non-light-duty vehicle engine service, and adjusted the *Lubesnet* 2-T/4-T estimates upward by the same amounts.

### 5.3. Proxy Choices for Commercial Automotive Lubricants Consumption

Commercial lubricants consumption is subdivided into two categories: on-highway and off-highway applications. Although miles-driven of medium- and heavy-duty vehicles would be a logical proxy for determining California's proportion of on-road HDMO lubricant consumption, such data is not available at the state level. Moreover, miles driven may be a poor proxy choice for non-farm off-road equipment, a substantial proportion of whose use may be relatively static.

With these issues in mind, and given the justification for the use of diesel fuel consumption in heavy duty transportation (which was discussed in Chapter 3), diesel fuel consumption was selected as the key proxy measure in on-road and off-road heavy duty applications.

The source of data to develop proxies for the various groups of commercial lubricants products was the U.S. Energy Information Administration. The EIA source employed for estimating on-road applications (namely HDMO multi-grade, HTF-other, commercial gear oils, and commercial greases, which are used in tractor-trailers and other heavy duty vehicles to lubricate their engines and drive trains) was the report titled *Prime Supplier Sales Volumes*. Within that report Kline selected the sales volumes of diesel fuel specifically associated with on-road applications, namely sales of Ultra-Low Sulfur (<15ppmS) and Low Sulfur (15-500ppmS) No.2 Diesel Fuel.

The primary applications for the rest of the commercial automotive products—HDMO mono-grade, HTF-hydraulic and transmission fluid, and HTF-tractor fluid—are in lubricating the engines and drive trains of agricultural and construction equipment, as well as providing the hydraulic fluid used in these vehicles' hydraulic systems. A different set of EIA data was used in this case, based on the series entitled *Sales of Distillate Fuel by End-Use.* Consumption data is provided in this report for both farm and off-road use of distillate fuel. Over the time period 2000-2010, these two off-road uses produce similar proxy proportions in terms of California's share of total consumption. In addition, the volumes of distillate consumed in each category is similar. Accordingly, Kline elected to use off-road distillate consumption as the primary proxy for these categories of heavy duty lubricants use.

| Table 5-3: Proxy Measures Used to Estimate California's Commercial Lubricants Consumption | | |
|---|---|---|
| **Source** | **Proxy** | **Associated Lubricant Products** |
| EIA | On-Road Diesel/Prime Supplier Volumes | HDMO Multi-Grade |
| EIA | On-Road Diesel/Prime Supplier Volumes | HTF-Other |
| EIA | On-Road Diesel/Prime Supplier Volumes | Commercial Gear Oils |
| EIA | On-Road Diesel/Prime Supplier Volumes | Commercial Greases |
| EIA | Off-Road Distillate Sales Volumes | HDMO Mono-Grade |
| EIA | Off-Road Distillate Sales Volumes | HTF-Hydraulic and Transmission |
| EIA | Off-Road Distillate Sales Volumes | HTF-Tractor |

**Table 5-3** summarizes the proxies selected to model California's share of U.S. consumption in each of the commercial lubricant product categories.

### 5.4. Proxy Choices for Industrial Lubricants Consumption

Proxy choices in the industrial category are complicated by the wide variety of industries using lubricants, and the broad array of non-lubricating uses to which they can be put (such as in process use and in metalworking fluid applications). Kline's approach was to develop an assessment of the distribution of industrial lubricants use by application and by the key 3-digit NAICS industry codes in Sections 31-33 (Manufacturing). As illustrated in **Table 5-4**, the broad array of lubricant applications, and industries in which they are used, requires a multiplicity of proxy choices, sourced from a variety of manufacturing and other statistical databases.

In each of the sub-chapters that follow, we discuss the nature of industrial lubricant use in each of the major process and non-process uses, the industries that consume them, and the proxies selected as most relevant for each application.

| Table 5-4: Proxy Measures Used to Estimate California's Industrial Lubricants Consumption | | |
|---|---|---|
| **Product** | **Source** | **Proxy** |
| Process Oil – Electrical | NAHB & CBIA | New Housing Starts |
| Process Oil – White Oil | BEA | Chemical Mfg. GDP |
| Process Oil – Rubber Oil | Census Bureau | Rubber Product Mfg. Shipments Value |
| Process Oil – Aromatic Oil | Census Bureau | Rubber Product Mfg. Shipments Value |
| Process Oil – Other Paraffinic | BEA | Chemical Mfg. GDP |
| Process Oil – Other Naphthenic | Census Bureau | Printing Ink Mfg. Shipments |
| Process Oil – Synthetic | BEA | Textile Mills and Textile Product Mills GDP |
| Industrial Engine Oil – Marine | EIA | Consumption of Total Marine Fuel Bunkers |
| Industrial Engine Oil – Railroad | EIA | Consumption of Distillates by Railroad Engines |
| Industrial Engine Oil – Natural Gas | EIA | Consumption of Natural Gas Pipeline and Distribution Fuel |
| Industrial Engine Oil – All Other | EIA | Average of Consumption of Off-Road and Farm Use of Distillate Fuel |
| MWF – Removal | BEA | Average of Motor Vehicle GDP and Fabricated Metal Products Mfg. GDP |
| MWF – Forming | BEA | Primary Metals Manufacturing GDP |
| MWF – All Other | BEA | Average of Primary Metals Mfg. GDP, Fabricated Metal Products Mfg. GDP, Machinery Mfg. GDP, and Motor Vehicle Mfg. GDP |
| Hydraulic Fluids – Non-Synthetic | EIA | Retail Industrial Electricity Consumption |
| Hydraulic Fluids – Synthetic | BEA | Primary Metals Manufacturing GDP |
| All Other Industrial Oils | EIA | Retail Industrial Electricity Consumption |
| Greases | EIA | Retail Industrial Electricity Consumption |

### 5.4.1. Process Oil - Electrical

Approximately 90 percent of electrical oil is used as transformer oils for transmission (step-up) and distribution (step-down) transformers, with the remaining 10 percent going to cable oils. Most step-up and step-down transformers are of the oil-filled type, and transformers are typically filled at transformer manufacturing plants before being shipped for installation. Around 75 percent of electrical oil in the United States is consumed by three large transformer OEMs: ABB, Cooper, and Howard Industries. None of these companies manufactures transformers in California, though manufacturing and servicing, particularly of distribution transformers, does occur on a smaller scale in the state. Due to the need for periodic regeneration of transformer oils to reinstate their dielectric performance, on-site and off-site processing and replenishment of transformer oils takes place. Thus it is difficult to develop a proxy measure that precisely captures the flow of electrical oils in a specific market, such as California.

Kline's estimate of California's electrical oil consumption indicates the amount of electrical oil used in new transformers installed in California each year. New housing starts was selected as the proxy for California as this statistic has long been used by the transformer manufacturing industry as the primary indicator of transformer demand. Based on statistics of the NAHB and the CBIA, California's share of this measure has ranged from 6.6 percent to 10.9 percent between 2000 and 2010. If anything, this measure may moderately overstate electrical oil consumption in California, since 2007 Economic Census data reports that California employment in NAICS Code 335311 (Power Transformer Manufacturing) ranged between 6.5 percent and 10.5 percent of the U.S. totals in the 1997, 2002, and 2007 reports.

### 5.4.2 Process Oil - White Oil

White oils are highly refined paraffinic or naphthenic oils used mainly in the chemical manufacturing industries, notably plastic resin, pharmaceuticals, cosmetics, and adhesives production. These industries use more than 85 percent of the white oils consumed in the United States, while another 12 percent is used by the food processing industry. The balance is used in a wide range of industries, including electrical equipment and textiles.

Chemical industry manufacturing industry GDP, sourced from the Bureau of Economic Analysis, was selected as the proxy for simulating California's white oil consumption, as this measure covers the industries that consume the preponderance of white oils in the United States. The Chemical Industry Manufacturing GDP (NAICS Code 325) shows that California's share of total U.S. output has ranged from 6 percent to 10.4 percent during the 2000-2010 time frame, with an average of around 9 percent. This correlates closely with manufacturing employment in the chemicals industry.

### 5.4.3. Process Oil – Rubber Oils

This section discusses the naphthenic and paraffinic oils used as process oils by the rubber and tire industries. Aromatic oils used by these industries are discussed in the next section.

Tire and rubber products use process oils in their formulations to improve the blending of the formulation, facilitate the incorporation of fillers and other additives, improve certain physical properties of the compound, and function as a low-cost product extender. These process oils are consumed in manufacturing both synthetic rubber polymers (e.g. SBR, EPDM) and in the mixing/compounding of tire components and rubber products. Kline estimates that approximately 70 percent of rubber oils are used in tire production, with the remaining 30 percent used in all other rubber products manufacture, including belts and hoses.

Kline selected rubber product manufacturing industry shipments value (NAICS: 3262) from the Economic Census as the proxy for this segment as this NAICS code covers the manufacturing of tires, rubber, and plastic hoses and belts, and other rubber products. In the 1997 Economic Census, California accounted for 4.1 percent of total U.S. rubber manufacturing industry shipments. This dropped to 3.5 percent in 2002, likely due to the closure of the Pirelli Hanford plant, and has remained at a similar level since then.

Tire manufacturing industry statistics were evaluated as proxies, but Kline sees issues with using these data. U.S. tire manufacturing shipments value is available at the 6-digit NAICS level (NAICS: 326211) from the Economic Census, but California state-level data is not available.

Tire manufacturing employment data for California is available and, as discussed previously in Chapter 2, California has very low levels of employment activity (about 0.2 percent of U.S. employment after the 2002 Census) in the tire manufacturing industry, with only one active tire-related production facility (Bridgestone's tread rubber and retreading plant in Long Beach). However, there are several rubber compounding and mixing plants located in California that would consume rubber process oils, so using a tire employment proxy of 0.2 percent will likely understate consumption.

Synthetic rubber manufacturing data (NAICS: 325212) was also evaluated as a proxy, as large amounts of rubber process oils are used in the companies covered in this NAICS code. However, California shipments data is unavailable.

### 5.4.4. Process Oil – Aromatic Oils

This segment covers all types of aromatic process oils, including distillate aromatic extract (DAE), residual aromatic extract (RAE), and treated residual aromatic extract (TDAE.) The vast majority of aromatic process oils (more than 90 percent) are used by the tire and rubber manufacturing industry. Very small amounts are used by other manufacturing industries, such as chemicals and textiles.

Aromatic oils are used in the formulations of tire and rubber products, similar to naphthenic and paraffinic rubber process oils. DAE was the most widely used process oil for rubber and tires until 2010, when the European Union banned its use due to its carcinogenicity. U.S. manufacturers of tires and rubber products for export to Europe were forced to switch to either naphthenic oils or to cleaner aromatic oils such as RAE and TDAE. DAE use for products sold in non-E.U. markets remains significant, but is in decline for environmental and health reasons.

The proxy selected for California rubber process oil consumption, rubber product manufacturing industry shipments value (NAICS: 3262) from the Economic Census, was also selected as the proxy for California aromatic oil consumption, as the consumption patterns are similar.

### 5.4.5. Process Oil – Other Paraffinic

More than 90 percent of paraffinic process oils in the United States are used by the chemical manufacturing industry in the formulation of products such as printing inks and adhesives. Another 10 percent is consumed by the agriculture, forestry, and fishing industries as spray oils, pesticides, and other agricultural chemicals.

Chemical manufacturing industry GDP was selected as the proxy for California paraffinic process oil consumption as this covers the industries that consume the most paraffinic oils in the United States.

### 5.4.6. Process Oil – Other Naphthenic

This segment covers naphthenic oils used in the chemical manufacturing industry, where printing inks and adhesives are the largest consumers. Very small amounts of naphthenic oils are also used in textile manufacturing. Meanwhile, naphthenic process oils used as electrical process oils, rubber and tire process oils, and metalworking fluids are excluded from this section and covered separately in different sections of this report.

Printing ink manufacturing industry shipments in NAICS Code 32591 from the Census Bureau was selected as the proxy for California, as around 70 percent of naphthenic oils in this section are used for printing inks. In the 2007 Economic Census, California accounted for 10.3 percent of U.S. printing ink manufacturing shipments.

### 5.4.7. Process Oil – Synthetic

Synthetic process oils are used in the textile manufacturing and rubber manufacturing industries. These include esters used in rubber processing and spin finishers used in textile applications.

Textile manufacturing and textile mill GDP was selected as the proxy for California synthetic process oil consumption, as Kline estimates that these segments account for approximately 80 percent of the total synthetic process oils consumed in the United States. From 2000 to 2011, California's share of U.S. textile manufacturing and textile mill GDP ranged from 5.5 percent to 6.4 percent.

### 5.4.8. Industrial Engine Oil – Marine

Marine propulsion is typically provided by either a diesel engine or steam turbine, with slow-speed diesel engines as the predominant motive unit. Engine oils used in marine diesels depend on engine type, a factor generally tied to the size of the vessel.

Large, ocean-going vessels are typically powered by slow-speed, two-stroke marine diesel engines fueled with Bunker C that typically have a crosshead design in which the cylinders are isolated from the crankcase. Two-stroke engine oils are used for cylinder and crankcase lubrication and need regular top-ups: cylinder lubricants are injected with each engine cycle and fully lost during combustion, while a portion of crankcase lubricants is also lost during operation.

Medium-speed, trunk piston engines require less space than larger, slow-speed engines, making them suitable for vessels such as cruise ships and roll-on/roll-off vessels. These engines use four-stroke engine oil for both the crankcase and cylinder, and regular top-ops are needed as a small amount of oil is burned during operation. Inland marine vessels such as tugboats, ferries, fishing boats, and others are typically powered by Electro-Motive Diesel (EMD) engines, which are similar to those used in railroad applications.

Since most marine engines are of the slow-speed, two-stroke diesel type, regular topping up of engine oil levels is required when these vessels reach port and load bunker fuel. Onboard filtration of engine oil generally avoids the necessity for oil changes; changing of the entire oil fill can only be done when the vessel is dry-docked, and even then it is not a common practice. As a result, viscosity-modified top-up lubricants are supplied on a routine basis at ports of call.

Marine fuel bunker consumption (a combination of marine residual and marine diesel supply) is a good proxy for marine engine oil demand as both fuel bunkers and lubricants consumption are tied to engine operating hours, and marine lubricant top-offs are generally delivered to the ship together with bunker fuel when it calls at port. These data were sourced from EIA's *Sales/Deliveries to Vessel Bunkering Customers* report, and include the supply of No.6 Bunker C and No.5 (Residual Fuel Oil) and No.4 Fuel (Marine Diesel) fuels. In California's ports, sales of residual bunker fuels dominate; only 7 percent of California bunker fuel supplied in the 2000-2010 time frame consisted of marine diesel fuel. Due to the significant activity at California's ports, and the propensity of the state's refineries to be long in fuel oil production, the bunker fuel proxy shows a significant proportion of U.S. sales being met from California; between 17 percent and 26 percent of U.S. marine bunkers sold have been supplied from California between 2000 and 2010, with an average close to 20 percent. This category, because of the very high implied proportion of marine lubricants sold in California, becomes important in the assessment of used oil recoverability or lack thereof.

### 5.4.9. Industrial Engine Oil – Railroad

These lubricants are used in the diesel engines of Class 1, regional, local, and other locomotives in the United States. There are two available proxies for estimating industrial engine oil consumption in California: the EIA's reported total consumption of fuel distillates by railroad engines, and the DOT's total ton-miles traveled of freight rail shipments originating and terminating in California. The EIA's total fuel distillate consumption by railroad engines was chosen as it encompasses all forms of rail travel, not just freight, which is the only type of rail travel covered by the DOT proxy.

The EIA's *Sales of Distillate Fuels by End Use* reports identify railroad consumption of diesel fuel for locomotives. Over the 10 years from 2000 to 2010, California's share of distillate fuel supplied for railroad use ranged from 3 percent to 4.6 percent.

### 5.4.10. Industrial Engine Oil – Natural Gas

Natural gas engines are used primarily in the interstate and intrastate transmission of natural gas for maintaining high pressure (typically of the order of 1,000 psig). In gas transmission compression stations, compressors are powered by either natural gas or electricity. In the case of electric-powered compressors, electricity may be supplied from the grid or generated on-site from available natural gas. Due to the remote location of many pipeline compression stations, the large majority function on direct or indirect natural gas supply for their operation. As discussed in Chapter 3, five large interstate pipelines serve California. Most of the compression stations on these systems are located outside California.

In addition to pipeline compression, natural gas engines are found at natural gas fields for primary pressurization. This may be necessary if wellhead pressure is low, or if expansion turbines are employed at the field for power generation or natural gas liquids recovery. In those circumstances, recompression of sales gas is necessary to comply with the minimum pressure requirements of gas gathering systems and transmission pipelines. Since California only produces about 10 percent of the natural gas it consumes, field compression is a minor component of natural gas engine use in the state.

In general, very little energy is expended in municipal and local natural gas distribution. Operating pressures are stepped down from high-pressure transmission line pressures at the city gates of these systems, resulting in available excess energy, which may drive expansion turbines. Municipal distribution systems operate in a range of 60psig to as low as 0.25psig; sales to industrial customers can be delivered either at mainline pressure, if bypassing the distribution utility, or above 60psig with appropriate pipeline design.

The EIA's assessment of natural gas pipeline and distribution system fuel consumption as reported in its *Natural Gas Consumption by End Use* reports was selected as the most appropriate proxy for California. Due to the specific circumstances of the California natural gas supply and distribution system, the state's share of U.S. natural gas supplied for transmission and distribution pipeline fuel use is low, ranging from 1 percent to 2.5 percent during 2000-2010, with an average of about 1.5 percent.

### 5.4.11. Industrial Engine Oil – All Other Uses

The other two applications of industrial engine oils are in piston-engine aircraft and in stationary industrial engines used to operate auxiliary equipment and power generation equipment. Of these two uses, stationary engines are by far the larger application; stationary engines are used predominantly in off-road applications, notably for agricultural irrigation pumps and other farm uses, as well in the mining, construction, and forestry businesses.

A blended proxy, based on the average of EIA's distillate use in farm and off-road applications, was employed for stationary engine use. This proxy shows California's share of total U.S. consumption as ranging between 6.9 percent and 12.3 percent from 2000 to 2010.

### 5.4.12. Metal Working Fluids (MWF) – Removal

The function of removal fluids is to lubricate and cool any process where ferrous or non-ferrous metal cutting is the primary machining technique. The fluid also functions to flush away metal cuttings, and serves as a corrosion preventative. Examples of metal-cutting operations are grinding, milling, drilling, boring, treading, broaching, gear shaping, and shaving.

MWF removal fluids are consumed directly and indirectly by a number of end-use industries. The most direct use of these fluids is by the fabricated metals industries, where commodity primary metal ingots, sheets, and tubes are transformed into more functional metal components. The other two industrial sectors that are both direct and indirect consumers of removal fluids are automotive parts manufacturing and machinery manufacturing. These manufacturers consume removal fluids in their operations and purchase fabricated metal products that used removal fluids in the process that made them.

On a national basis, Kline estimates that approximately 85 percent of removal fluids are consumed by the fabricated metals and automotive parts manufacturing. With this estimate in mind, the proxy for removal fluids was set as the average GDP of motor vehicle parts and fabricated metal products manufacturing, based on BEA statistics. The proxy shows California's share of total U.S. MWF – removal fluid consumption ranged from 5 percent and 6.4 percent between 2000 and 2011.

### 5.4.13. MWF – Forming

Forming fluids are used in metalworking operations that involve changing the shape and contour of metals by bending, stretching, pounding, and squeezing. Forming fluids include rolling oils, drawing and stamping compounds, forging compounds, die-casting compounds, and hydroforming fluids. Example semi-finished and finished products that undergo said forming operations are ferrous and aluminum ingots, coils, pipes, car door panels, mufflers, and air conditioning ducts.

These fluids are most commonly used in primary metals production, as it is estimated to represent approximately nearly 60 percent of total forming fluid consumption. The other significant consumers of forming fluids are the fabricated metals and motor vehicle parts manufacturing industries, each accounting for an estimated 20 percent of total forming fluid demand. Considering that primary metals comprises the vast majority of forming fluid demand, the GDP of the primary metals industry was chosen as the proxy for California's MWF – forming fluid consumption. The proxy shows California's share of U.S. consumption ranging between 3.1 percent and 5.5 percent over the 2000-2011 time frame.

### 5.4.14. MWF – All Other

Two other types of metal working fluids fall into the MWF – "all other" category: protecting and treating fluids. Protecting fluids are used to temporarily shield metal surfaces from air, water, and other corrosion-inducing materials. The protection period typically ranges from several weeks for interim protection between metalworking operations, to several years for finished components. The most common protecting fluids are corrosion preventives that are applied to iron, steel and, to a lesser extent, such non-ferrous metals as copper, aluminum, and brass. In general, treating fluids are used either to cool or heat metal. These fluids are used at all levels of metalworking, from basic production to metal finishing. Product examples are springs, tools, alloyed structural steel parts, gears, axles, and so forth. The typical process is quenching, which involves reducing the temperature of hot metal products in a rapid and controlled manner by immersing these products in a quenching bath.

The consumption of protecting and treating fluids is fairly uniform across the following end-use industries which consume these fluids: fabricated metals (37 percent of demand), primary metals (25 percent of demand), motor vehicle parts manufacturing (23 percent of demand), and machinery manufacturing (15 percent of demand). The proxy used to estimate California's share of MWF – All Other consumption is the simple average of these end-use industries' contribution to GDP. This proxy shows California's share of manufacturing GDP ranging between 5.3 percent and 7.4 percent from 2000 to 2011.

### 5.4.15. Hydraulic Fluids – Non-Synthetic

Hydraulic fluids are used in hydraulic pumps and motors that are found on a wide variety of mobile and stationary industrial equipment used in practically all manufacturing industries. Kline estimates that more than 70 percent of industrial hydraulic fluids in the Unites States are consumed by five industries: transportation equipment manufacturing, machinery manufacturing, mining, primary metals manufacturing, and rubber and plastic products manufacturing industries. The remaining 30 percent is consumed by a wide range of manufacturing industries, including wood and paper products, fabricated metal products, and electrical equipment.

Hydraulic fluid formulations fall into three broad categories: mineral oil, fire-resistant, and biodegradable. Most hydraulic fluids are formulated using mineral oils (non-synthetic). Fire-resistant and biodegradable hydraulic fluids are classified as synthetic hydraulic fluids and are covered in the next section.

Retail industrial electricity consumption was selected as the proxy for California's non-synthetic hydraulic fluids consumption in order to reflect their widespread use in various types of manufacturing industries. This proxy shows California's share of U.S. consumption in the range of 4.8 percent to 6.3 percent from 2000 to 2011.

### 5.4.16. Hydraulic Fluids – Synthetic

The two main types of synthetic hydraulic fluids are fire-resistant hydraulic fluids and biodegradable hydraulic fluids. Fire-resistant hydraulic fluids are used in select industries, such as underground mining, steel mills, and die-casting plants, where minimizing the risk of fire is critical. Meanwhile, biodegradable hydraulic fluids are used in applications such as forestry, marine, agriculture, and offshore drilling, where leaking fluid coming into contact with the ground or water is undesirable.

Primary metals manufacturing GDP was selected as the proxy for California synthetic hydraulic fluid consumption. The primary metals manufacturing and the mining industries are the largest users of synthetic hydraulic fluids, and California's share of U.S. manufacturing GDP ranges between 3 and 5 percent from 2000 to 2010 for both of these industries. Mining use of these fluids is in underground applications, such as in hydraulic roof supports. Since California has very limited underground mining activity, primary metals manufacturing was the preferred proxy choice. This proxy shows California's share of synthetic hydraulic fluid consumption as ranging from 3.1 percent to 5.5 percent during 2000-2011.

### 5.4.17. All Other Industrial Oils

This category includes turbine oils, gear oils, compressor and refrigeration oils, heat transfer fluids, and all other types of industrial oils not covered in the previous categories.
While the formulations and uses of these oils are very different, they are all used widely across all facets of the manufacturing and primary production industries. Consequently a broad proxy,

retail industrial electricity consumption, was selected to reflect the widespread use of these oils for all types of manufacturing industries.

### 5.4.18. Greases

Industrial greases are used to lubricate moving parts such as bearings and open and semi-enclosed gears. The mining, off-highway transportation (i.e. marine, railroads, aviation), transportation equipment manufacturing, and primary metals manufacturing industries account for 65 percent of U.S. industrial grease demand.

Retail industrial electricity consumption was selected as the proxy for California industrial grease consumption to reflect its widespread use throughout industry.

# 6. CALIFORNIA LUBRICANTS CONSUMPTION ESTIMATES

## 6.1. Methodological Approach

Kline's approach to developing estimates of historical and future consumption of lubricants in California followed four steps:

- Collecting data from proprietary Kline sources on past and projected U.S. lubricants consumption, covering the time period 2000-2020, subdivided into the key applications within three principal categories of lubricants use: consumer automotive, commercial automotive, and industrial
- Researching possible proxies for determining California's share of total U.S. consumption in each specific lubricant application, and selecting the proxy which was believed to be most apposite
- Applying the selected proxies to year-by-year U.S. lubricant consumption in each category and application, to derive estimated historical and projected California consumption on an annual basis
- Summing the California lubricant consumption estimates by year, by lubricant application, by the three principal categories of lubricants, and in total

Thereafter, Kline compared the results of its independent assessment of historical California lubricants consumption with consumption figures published by CalRecycle. Due to the different definitions attributed to lubricants by Kline and CalRecycle, Kline's estimates of California consumption were reconstituted using the CalRecycle definitions, to enable a more direct means of comparison.

Kline also compared its historical estimates of Californian lubricants demand with state-level statistics on automotive and industrial lubricants consumption available from EIA's *SEDS* database. Again, there are material differences between Kline's and EIA's estimating methodologies, and the necessary adjustments that were made to reconcile them are discussed.

The results of each of these methodological processes are discussed in the next two sections of Chapter 6.

## 6.2. Summary of Kline's Consumption Estimates

Kline's Excel-based **California Lubricants Consumption Model** is an accompanying product to this Part 1 Report. It provides historical data and forecasts of U.S. and California lubricants consumption by application within the three major categories of lubricants use from 2000-2020, in considerable detail. In this report, therefore, we summarize the salient findings and conclusions of the model results.

**Table 6-1** presents a snapshot of Kline's estimate of historical California lubricants consumption from 2000 to 2011, divided between the three principal categories of lubricants use: consumer automotive, commercial automotive, and industrial.

| Table 6-1: Kline Estimates of California Lubricants Consumption (Million Gallons) | | | | |
|---|---|---|---|---|
| **Year** | **Consumer Automotive** | **Commercial Automotive** | **Industrial** | **Total** |
| 2000 | 93.9 | 75.2 | 96.6 | **265.7** |
| 2001 | 95.3 | 80.6 | 95.5 | **271.4** |
| 2002 | 93.2 | 65.3 | 80.2 | **238.7** |
| 2003 | 91.4 | 55.5 | 79.9 | **226.8** |
| 2004 | 88.2 | 62.0 | 87.1 | **237.3** |
| 2005 | 92.4 | 62.3 | 88.1 | **242.8** |
| 2006 | 89.8 | 59.1 | 86.7 | **235.6** |
| 2007 | 80.8 | 48.0 | 88.2 | **217.0** |
| 2008 | 74.0 | 41.7 | 83.6 | **199.3** |
| 2009 | 66.1 | 39.7 | 78.4 | **184.2** |
| 2010 | 70.1 | 39.9 | 82.7 | **192.7** |
| 2011 | 71.9 | 41.0 | 83.9 | **196.8** |
| *Source: Kline estimates* | | | | |

Several key conclusions become evident from Kline's projections of California's historical lubricants consumption:

- There is a downward trend in the consumption of all three primary categories in the eleven years from 2000-2011, which follows a similar trend in the overall U.S. market
- Of the three primary categories, commercial automotive exhibits the largest decline between the combined peak (2001) and valley (2009) years.
- Commercial automotive drops 51 percent between 2001 and 2009, compared with 27 percent in consumer automotive and 18 percent in industrial use.
- Consumption in all three categories has remained relatively stable since 2008, at an average of 194 million gallons, with 2009 as the lowest year, followed by a modest recovery in overall consumption in 2010 and 2011.

As will be noted in the next section of Chapter 6, the above trends are not dissimilar from those reported by CalRecycle and EIA in California, though the totals for consumption differ. Several overarching forces have contributed to the trends noted above, including:

- In the consumer and commercial automotive categories the decline in oil change frequency, which has resulted from a combination of increasing OEM-recommended drain intervals, greater use of synthetics, and general economic conditions, such as the increase in oil and lubricants prices
- A drop in California's registered vehicle fleet between 2009 and 2010 (DOT/FHA 2011 registration data are as yet unpublished); registrations of all light duty vehicles fell from 30.5 to 28.6 million units between 2009 and 2010, while heavy truck registrations also fell
- A noticeable increase in the median age of the vehicle fleet; according to NADA/R.L. Polk statistics the median age of the light duty vehicle fleet grew from 8.9 years in 2001

to 10.8 years in 2011, which is suggestive of the challenging economic conditions faced by consumers in the first decade of the 2000s

- Increasing use of closed-loop lubricant recovery and recycling systems in commercial and industrial applications

Though comparisons cannot be made with other sources, Kline's estimates of California's future lubricants consumption mirror projected trends in the overall U.S. market. Between 2011 and 2020, Kline projects essentially no change in combined consumer and commercial automotive consumption in California, as recovery in the state's registered vehicle population is offset by continuing advances in engine lubricating efficiency. Conversely, the demand for industrial lubricants in California is projected by Kline to grow from 83.9 million gallons in 2011 to 99.4 million gallons in 2020. This 18 percent increase results from the expected recovery in manufacturing activity across the nation, as California's share of U.S. industrial lubricants consumption remains essentially unchanged at between 6.6 percent and 6.8 percent.

## 6.3. Comparisons with Other Estimates

As noted in other chapters of this report, two sources of data are available in the public domain, in addition to Kline's estimates, that report historical lubricants consumption in California. Each has a distinctly different methodological approach. As a result, they cannot be compared directly with one another or with Kline's estimates without attempting to adjust for the differences in lubricants definitions and in the data-development processes used.

### 6.3.1. CalRecycle Estimates

CalRecycle's *Used Oil Recycling Rate Annual Reports* provide annual data collected from lubricating oil manufacturers in California regarding the consumption of "lubricants" and "industrial" oils. "Lubricants" and "industrial" oils are defined in California as follows:

> *"Oil is categorized as lubricating oil and industrial oil. Lubricating oil includes, but is not limited to, any oil intended for use in an internal combustion engine crankcase, transmission, gearbox, or differential in an automobile, bus, truck, vessel, plane, train, heavy equipment, or other machinery powered by an internal combustion engine (Public Resources Code [PRC] section 48618). Industrial oil includes, but is not limited to, any compressor, turbine, or bearing oil, hydraulic oil, metalworking oil, or refrigeration oil. Industrial oil does not include dielectric fluids (PRC section 48616)."*

The principal distinctions between Kline and CalRecycle's definitions are summarized in **Table 6-2**.

**Table 6-2: Reconciliation of Kline and CalRecycle Lubricants Definitions**

| Source | Kline Nomenclature | | | *CalRecycle Definitions* | | |
|---|---|---|---|---|---|---|
| **Category** | **Consumer Automotive** | **Commercial Automotive** | **Industrial** | ***"Lubricants"*** | ***"Industrial"*** | ***Excluded*** |
| **Applications** | PCMO | HDMO | | *Crankcase* | | |
| | 2-T/4-T | | | *Sump/Crankcase* | | |
| | ATF | HDF | | *Transmission* | *60% of Commercial HTF* | |
| | Gear Oils | Gear Oils | | *Gearbox* | | |
| | Greases | Greases | | *Bearings* | | |
| | | | Process Oils | | *Non-electrical Process Oils* | *Electrical Oils* |
| | | | Industrial Engine Oils | *ICE & Related* | *Nat. Gas Compressor Oils* | |
| | | | MWF | | *MWF* | |
| | | | Hydraulic Oils | | *Multiple* | |
| | | | All Other Ind. Oils | | *Multiple* | |
| | | | Greases | | *Multiple* | |

By the CalRecycle definition, all internal combustion engine (ICE)-related uses are included in "lubricants" regardless of whether they are mobile or static; this definition also is independent of the type of consumer involved. In itself, this should not impact total estimates of California lubricants consumption, since it merely transfers certain types of oils from Kline's commercial automotive and industrial categories into "lubricants," with some counter-movement from Kline's commercial automotive category to "industrial." The second definitional distinction is in "industrial," where CalRecycle completely excludes dielectric fluids (notably transformer oils). This distinction clearly impacts volume estimation where, *mutatis mutandis*, Kline's estimates should exceed CalRecycle's reported numbers by the amount of electrical process oils consumed in California.

Based on the CalRecycle definitions, Kline has determined "adjusted" California consumption estimates, using the above definition, which then may be compared directly with the data reported by CalRecycle. This comparison appears in **Table 6-3**. Kline's "adjusted lubricants" estimates for California, in aggregate over the 11 years from 2000-2010, exceed CalRecycle's reported cumulative sales in this category by 6.3 percent, with a standard deviation of 5.4 percent.

The difference between the Kline Adjusted and CalRecycle "lubricants" estimates, while not insubstantial, may in part be explained by how reporting manufacturers interpret the State of California's "Oil" definition. In the area of commercial hydraulic fluids, for example, significant volumes are used in non-transmission-related vehicle functions, such as bucket-loader arms. Kline has attempted to adjust its consumption estimates for such distinctions in developing an "apples-to-apples" comparison with the CalRecycle data, but gray areas remain open to interpretation.

| Table 6-3: Comparison of Kline's Adjusted Estimates and CalRecycle's Reported California "Oil" Consumption (Million Gallons) | | | | |
|---|---|---|---|---|
| **Year** | **"Lubricants"** | | **"Industrial"** | |
| | **Kline Adjusted** | **CalRecycle** | **Kline Adjusted** | **CalRecycle** |
| 2000 | 175.6 | 154.3 | 81.9 | 155.7 |
| 2001 | 181.0 | 163.6 | 82.3 | 149.1 |
| 2002 | 168.2 | 168.0 | 62.2 | 147.1 |
| 2003 | 157.2 | 150.2 | 60.9 | 135.8 |
| 2004 | 160.4 | 150.5 | 67.5 | 122.6 |
| 2005 | 166.8 | 153.7 | 67.2 | 123.1 |
| 2006 | 161.1 | 152.8 | 66.8 | 116.4 |
| 2007 | 142.1 | 150.0 | 67.3 | 95.3 |
| 2008 | 130.7 | 114.6 | 62.7 | 143.5 |
| 2009 | 118.3 | 113.1 | 60.8 | 115.6 |
| 2010 | 123.0 | 113.4 | 63.4 | 119.6 |
| *Source: Kline, CalRecycle* | | | | |

While the differences in Kline and CalRecycle's estimates of California's "lubricants" consumption are relatively minor, this is not the case in the industrial category, where the cumulative consumption volumes reported by CalRecycle from 2000 to 2010 are 192 percent of Kline's adjusted sales estimates over the same period. This outcome is not unexpected, since reservations have been expressed by CalRecycle concerning the double-counting of industrial lubricants sales, due to the different reporting methods used for non-taxable sales of lubricants to this market segment.

### 6.3.2. EIA's *SEDS* Estimates

A second public source of statistics relating to California's historical lubricants consumption is the EIA's *State Energy Data System (SEDS).* State-by-state lubricant consumption data may be found in *SEDS* under the codes LUACP (automotive) and LUICP (industrial) from 1960 to 2010. Despite the availability of this data, it must be treated with reservation. First, the data reported by EIA are believed to represent the volumes of base stocks supplied to blenders, not finished lubricants consumption. As a result, Kline believes that these volumes in most cases exclude additive content and associated diluent oils, as well as re-refined oils and some synthetics. Second, the California percentages of total U.S. consumption have not changed from year to year since 1980, though those percentages differ between automotive (9.9 percent) and industrial (7.0 percent); the consistency of these percentages suggests that state-level *SEDS* information is based on a formulaic proportioning of total U.S. consumption, as opposed to reflecting actual state-by-state data.

With the above caveats in mind, Kline has attempted to bring the EIA *SEDS* data to an equal footing with the Kline estimates, by adjusting the EIA data upwards to account for the estimated amounts of additives and diluent oils in the automotive (typically about 17 percent of finished lubricant volumes) and industrial (some 7 percent of finished lubricant volumes) categories. The results of adjusting the EIA *SEDS* data for additive content are shown in **Table 6-4**.

| Table 6-4: Comparison of Kline's and EIA's Adjusted *SEDS* Estimates of California Lubricants Consumption (Million Gallons) | | | | |
|---|---|---|---|---|
| **Year** | **Automotive** | | **Industrial** | |
| | **Kline** | **EIA Adjusted** | **Kline** | **EIA Adjusted** |
| 2000 | 169.1 | 149.7 | 96.6 | 99.7 |
| 2001 | 175.9 | 137.0 | 95.5 | 91.4 |
| 2002 | 158.5 | 135.3 | 80.2 | 90.3 |
| 2003 | 146.9 | 125.0 | 79.9 | 83.3 |
| 2004 | 150.2 | 126.5 | 87.1 | 84.3 |
| 2005 | 154.8 | 125.8 | 88.1 | 83.8 |
| 2006 | 148.9 | 122.4 | 86.7 | 81.5 |
| 2007 | 128.8 | 126.3 | 88.2 | 84.1 |
| 2008 | 115.7 | 117.2 | 83.6 | 78.0 |
| 2009 | 105.7 | 105.3 | 78.4 | 70.0 |
| 2010 | 110.0 | 116.9 | 82.7 | 77.7 |
| *Source: Kline, EIA/SEDS* | | | | |

Even with the additive adjustments applied to EIA's *SEDS* data, their reported consumption in California falls a little below Kline's unadjusted sales estimates. In the Automotive category, Kline's California cumulative consumption from 2000 to 2010 (2011 data is not yet available in *SEDS*) is 12.8 percent higher than the additive-adjusted EIA figures, with a 10.9 percent standard deviation. In the industrial category, Kline's California cumulative consumption from 2000 to 2010 is only 2.5 percent higher than the adjusted SEDS estimates, with a 6.2 percent standard deviation.

Given the very large difference between Kline's estimates of California's industrial lubricants consumption and the data of CalRecycle, even accounting for adjusting Kline's overall lubricants estimates to be consistent with CalRecycle's definitions of "lubricants" and "industrial," the close relationship between the unadjusted Kline and additive-adjusted EIA *SEDS* figures for industrial consumption is encouraging. Though the consistent 7 percent of U.S. industrial lubricants consumption that EIA has consistently applied to California is clearly not fact-based, since this percentage has not varied since 1980, this assumption is not necessarily grounds for complete rejection of EIA's figures. It is clearly not coincidental that, in addition to the very close correspondence between Kline's and EIA's additive-adjusted industrial consumption estimates, the standard deviation of annual estimates between them is moderately low.

### 6.4 Part 2 Study of Recoverable Used Oil in California

A companion work product, which is associated with this Part 1 report on California's lubricants consumption, is Kline's Part 2 report on the expected volumes of in-state used oil generation. The Part 2 report will apply segment-specific estimates of used oil recoverability over time to the consumption data developed in the **California Lubricants Consumption Model**. This approach will permit Kline to create yearly estimates of recoverable used oil in California, by application and end-use category. By comparing Kline's estimates of theoretically recoverable used oil in California with actual CalRecycle and DTSC data on used oil collections the difference between them will provide an implicit assessment of past volumes of “uncollected” waste oil in the state which, by default, are presumed to be improperly disposed.

Research is currently ongoing within Kline regarding recent levels of U.S. lubricating oil losses-in-use and recoverability within the key automotive and industrial applications. Due to the schedule for completion of this research, final data on U.S. lubricating oil consumption-in-use and, by difference, implied used oil recoverability will not be available until after the publication date of this Part 1 report. As a result, Kline has elected to publish this study in two parts, with the Part 2 report on California’s estimated “collectable” waste oil generation due for publication approximately two months after the date of this Part 1 report.

# APPENDICES

## Appendix A - Key Demographic and Macroeconomic Data

| Appendix A: Key Demographic and Macroeconomic Data | | | | | | |
|---|---|---|---|---|---|---|
| **Source** | **Measure** | **Year** | **Units** | **CA** | **U.S.** | **CA as % of U.S.** |
| Census Bureau | Population | 2011 | Thousand | 37,692 | 311,592 | **12.1%** |
| Census Bureau | Housing units | 2010 | Thousand | 13,680 | 131,704 | **10.4%** |
| Census Bureau | Private non-farm establishments | 2009 | Thousand | 857.8 | 7,433.5 | **11.5%** |
| Census Bureau | Number of firms | 2007 | Thousand | 3,425 | 27,093 | **12.6%** |
| Census Bureau | Manufacturer's shipments | 2007 | $ Billion | 491.4 | 5338.3 | **9.2%** |
| Census Bureau | Merchant wholesaler sales | 2007 | $ Billion | 598.5 | 4174.3 | **14.3%** |
| BEA | GDP | 2010 | Billion $ | 1,878 | 14,416 | **13.0%** |
| BEA | Mining GDP | 2010 | Billion $ | 16.2 | 240 | **6.8%** |
| BEA | Agricultural GDP | 2010 | Billion $ | 29.2 | 157 | **18.6%** |
| BEA | Utility GDP | 2010 | Billion $ | 28.0 | 265 | **10.6%** |
| BEA | Construction GDP | 2010 | Billion $ | 57.4 | 512 | **11.2%** |
| BEA | Manufacturing GDP | 2010 | Billion $ | 214.3 | 1,702 | **12.6%** |
| BEA | Mfg. GDP - Non-metallic minerals | 2010 | Billion $ | 2.78 | 35.11 | **7.9%** |
| BEA | Mfg. GDP -Primary metals | 2010 | Billion $ | 1.43 | 43.16 | **3.3%** |
| BEA | Mfg. GDP - Metal fabrication | 2010 | Billion $ | 10.59 | 120.59 | **8.8%** |
| BEA | Mfg. GDP - Machinery | 2010 | Billion $ | 9.14 | 139.69 | **6.5%** |
| BEA | Mfg. GDP -Computers & electronics | 2010 | Billion $ | 65.03 | 264.86 | **24.6%** |
| BEA | Mfg. GDP - Electrical | 2010 | Billion $ | 2.86 | 44.19 | **6.5%** |
| BEA | Mfg. GDP - Motor vehicle | 2010 | Billion $ | 1.46 | 54.8 | **2.7%** |
| BEA | Mfg. GDP - Food & beverage | 2010 | Billion $ | 20.76 | 207.44 | **10.0%** |
| BEA | Mfg. GDP - Oil & coal products | 2010 | Billion $ | 36.61 | 171.8 | **21.3%** |
| BEA | Mfg. GDP - Chemicals | 2010 | Billion $ | 20.26 | 226.05 | **9.0%** |
| BEA | Mfg. GDP - Plastics & rubber | 2010 | Billion $ | 4.53 | 66.46 | **6.8%** |
| BEA | Mfg. GDP - All other industries | 2010 | Billion $ | 38.85 | 327.85 | **11.8%** |

# Appendix B - Demographic and Macroeconomic Sources

| Appendix B: Demographic and Macroeconomic Sources | | |
|---|---|---|
| **Source** | **Measure** | **URL Link** |
| Census Bureau | Population | http://quickfacts.census.gov/qfd/states/06000.html |
| Census Bureau | Housing units | http://quickfacts.census.gov/qfd/states/06000.html |
| Census Bureau | Private non-farm establishments | http://quickfacts.census.gov/qfd/states/06000.html |
| Census Bureau | Number of firms | http://quickfacts.census.gov/qfd/states/06000.html |
| Census Bureau | Manufacturer’s shipments | http://quickfacts.census.gov/qfd/states/06000.html |
| Census Bureau | Merchant wholesaler sales | http://quickfacts.census.gov/qfd/states/06000.html |
| BEA | GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mining GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Agricultural GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Utility GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Construction GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Manufacturing GDP | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Non-metallic minerals | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP -Primary metals | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Metal fabrication | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Machinery | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP -Computers & electronics | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Electrical | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Motor vehicle | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Food & beverage | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Oil & coal products | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Chemicals | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - Plastics & rubber | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |
| BEA | Mfg. GDP - All other industries | http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=1 |

# Appendix C - Key Manufacturing and Energy Data

| Appendix C: Key Manufacturing and Energy Data | | | | | | |
|---|---|---|---|---|---|---|
| **Source** | **Measure** | **Year** | **Units** | **CA** | **U.S.** | **CA as % of U.S.** |
| Census Bureau | Tire Mfg. Establishments (326211) | 2007 | Number | 3 | 137 | **2.2%** |
| Census Bureau | Tire Mfg. Establishments (326211) | 2007 | Employees | 106 | 49,715 | **0.2%** |
| Census Bureau | Tire Retreading Ests. (326212) | 2007 | Number | 40 | 523 | **7.6%** |
| Census Bureau | Tire Retreading Ests. (326212) | 2007 | Employees | 575 | 7,974 | **7.2%** |
| Census Bureau | All Other Rubber Prods (3262) | 2007 | Number | 188 | 1,551 | **12.1%** |
| Census Bureau | All Other Rubber Prods (3262) | 2007 | Employees | 6,606 | 91,019 | **7.3%** |
| Census Bureau | Transformer Mfg. Ests. (335311) | 2007 | Number | 37 | 287 | **12.9%** |
| Census Bureau | Transformer Mfg. Ests. (335311) | 2007 | Employees | 1,526 | 22,521 | **6.8%** |
| DOE/EIA | Total energy consumption | 2010 | Trillion Btu | 7,826 | 97,711 | **8.0%** |
| DOE/EIA | Industrial energy consumption | 2010 | Trillion Btu | 1,765 | 30,391 | **5.8%** |
| DOE/EIA | Industrial retail electricity sales | 2010 | Trillion Btu | 168.2 | 3,313 | **5.1%** |
| DOE/EIA | Distillate sales for vessel bunkers | 2010 | Million Galls. | 81.7 | 1,343 | **6.1%** |
| DOE/EIA | Resid sales for vessel bunkers | 2010 | Million Galls. | 1,060 | 4,206 | **25.2%** |
| DOE/EIA | All marine bunker fuel sales | 2010 | Million Galls. | 1,142 | 5,549 | **20.6%** |
| DOE/EIA | Railroad use of distillate fuel | 2010 | Million Galls. | 252 | 2,084 | **12.1%** |
| DOE/EIA | Farm use of distillate fuel | 2010 | Million Galls. | 213 | 2,910 | **7.3%** |
| DOE/EIA | Industrial use of distillate fuel | 2010 | Million Galls. | 79.6 | 2,043 | **3.9%** |
| DOE/EIA | Off-highway use of distillate fuel | 2010 | Million Galls. | 196 | 2,132 | **9.2%** |
| DOE/EIA | Natural gas for pipeline & dist'n use | 2010 | BCF | 9.74 | 668.8 | **1.5%** |

# Appendix D - Manufacturing and Energy Sources

| Appendix D: Manufacturing and Energy Sources | | |
|---|---|---|
| **Source** | **Measure** | **URL Link** |
| Census Bureau | Tire Mfg. Establishments (326211) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | Tire Mfg. Establishments (326211) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | Tire Retreading Ests. (326212) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | Tire Retreading Ests. (326212) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | All Other Rubber Prods (3262) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | All Other Rubber Prods (3262) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | Transformer Mfg. Ests. (335311) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| Census Bureau | Transformer Mfg. Ests. (335311) | http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1 |
| DOE/EIA | Total energy consumption | http://www.eia.gov/state/seds/hf.jsp?incfile=sep_fuel/html/fuel_te.html |
| DOE/EIA | Industrial energy consumption | http://www.eia.gov/state/seds/hf.jsp?incfile=sep_fuel/html/fuel_te.html |
| DOE/EIA | Industrial retail electricity sales | http://www.eia.gov/state/seds/hf.jsp?incfile=sep_sum/html/sum_btu_ind.html |
| DOE/EIA | Distillate sales for vessel bunkers | http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=KD0VVBNUS1&f=A |
| DOE/EIA | Resid sales for vessel bunkers | http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=KPRVVBNUS1&f=A |
| DOE/EIA | All marine bunker fuel sales | Aggregate total of two previous lines |
| DOE/EIA | Railroad use of distillate fuel | http://www.eia.gov/dnav/pet/pet_cons_821dst_dcu_SCA_a.htm |
| DOE/EIA | Farm use of distillate fuel | http://www.eia.gov/dnav/pet/pet_cons_821dst_dcu_SCA_a.htm |
| DOE/EIA | Industrial use of distillate fuel | http://www.eia.gov/dnav/pet/pet_cons_821dst_dcu_SCA_a.htm |
| DOE/EIA | Off-highway use of distillate fuel | http://www.eia.gov/dnav/pet/pet_cons_821dst_dcu_SCA_a.htm |
| DOE/EIA | Natural gas for pipeline & dist'n use | http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm |