Final Report on Direct Impacts Model (DIM) Analysis of the California Used Oil Market

CalRecycle
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1 Introduction

In 2009 California enacted SB 546, which mandated CalRecycle to submit a report to the Legislature including a life cycle assessment of used lubricating and industrial oil management from generation through collection and recycled product recovery. CalRecycle will also provide recommendations for policy changes that may be necessary to promote increased collection and responsible management of used oil in California.

To support this effort, CalRecycle awarded a life cycle assessment contract to the University of California Santa Barbara and an economic study contract to ICF International. ICF has worked closely with CalRecycle, the life cycle contractor, and other CalRecycle contractors and stakeholders to develop specific policy scenarios to be modeled by ICF and UC Santa Barbara to fully understand the implications of requirements under SB 546 and related potential policy changes.

This report presents the methodology and results of the direct impacts model that ICF developed to analyze how different policy scenarios would affect the California used oil market. Inputs to the model have been calibrated with a UC Santa Barbara material flow analysis for used oil generation, collection, and product recovery for 2007-2011. The model was designed to forecast scenario values through 2030 that also serve as inputs to the life cycle assessment analysis of 2030 impacts, and a separate ICF cost-benefit analysis. This report on the direct impacts analysis of the California used oil market is divided into four sections.

1. Introduction
2. Direct impacts model overview
3. Direct impacts model functional relationships, key inputs, and data limitations
4. Scenario and sensitivity analysis

2 Direct Impacts Model Overview

The direct impacts model combines data from the UC Santa Barbara material flow analysis, Kline data on lube oil and industrial oil markets, California data on vehicle miles traveled, and other data and estimates used to derive baseline and scenario trends through 2030 for California lube and industrial oil sales and used oil collection and products recovered. This report describes relationships and results in the model, which includes 10 functionally connected Excel worksheets.[1]

1. The **Input-Output** worksheet allows model users to enter parameter values for a baseline and a scenario/sensitivity analysis forecast.
2. The **Summary** worksheet records baseline and scenario/sensitivity inputs for a specific analysis; highlights—with bold “**YES**”—scenario/sensitivity input parameters that vary from the corresponding baseline input value; and records key output values associated with the analysis. This worksheet can be copied into a new worksheet to maintain a record of the input and output changes associated with any specific scenario/sensitivity analysis.

3. The **Lube Oil Baseline** worksheet forecasts lube oil sales based on California vehicle miles traveled data for 2007-2011 and baseline input values entered in the Input-Output worksheet. DIM results are compared with 2007-2011 material flow analysis data, and the 2011-2030 forecast is calibrated to be consistent with 2011 material flow analysis results.
4. The **Lube Oil Scenario** worksheet is the same as the lube oil baseline worksheet except the scenario worksheet references scenario inputs in the Input-Output worksheet.
5. The **Industrial Oil Baseline** worksheet forecasts industrial oil sales based on Kline data for 2007-2011 and baseline input values in the Input-Output worksheet.
6. The **Industrial Oil Scenario** worksheet is the same as the industrial oil baseline except the industrial oil scenario references scenario inputs in the Input-Output worksheet.
7. The **Collection Baseline** worksheet forecasts collectible and collected used oil based on sales forecasts from the lube oil and industrial oil baseline worksheets and baseline input values in the Input-Output worksheet.
8. The **Collection Scenario** worksheet is the same as the collection baseline except the scenario worksheet references forecasts from lube and industrial oil scenario worksheets and scenario inputs in the Input-Output worksheets. The collection scenario worksheet also references elasticity of supply estimates that interact with scenario inputs for Do-It-Yourselfers (DIY) and non-DIY lube oil and industrial oil incentive payments to determine how different incentives are expected to affect used oil collection for recycled product recovery.
9. The **Recovery Baseline** worksheet forecasts re-refined oil, marine distillate oil/light fuels, asphalt flux, and recycled fuel oil recovered from used oil, based on forecasts for collected California used oil from the collection baseline worksheet and baseline input values in the Input-Output worksheet.
10. The **Recovery Scenario** worksheet is the same as the recovery baseline except the Recovery Scenario references forecasts for collected California used oil from the collection scenario worksheet and scenario inputs in the Input-Output worksheet. The Recovery Scenario also references cross-elasticity estimates for recovered products versus virgin material products from crude oil refineries. These cross-elasticity estimates interact with scenario inputs for recovered and virgin product fees and incentive payments to determine how different fees and incentives affect the mix of products recovered.

Table 2-1: Overview of Direct Impacts Model (DIM) Structure

Input-Output Worksheet	Eight Forecast Worksheets
Lube Oil	Lube Oil Baseline
	Lube Oil Scenario
Industrial Oil	Industrial Oil Baseline
	Industrial Oil Scenario
Used Oil Collection	Collection Baseline
	Collection Scenario
Used Oil Product Recovery	Recovery Baseline
	Recovery Scenario

Column A of the input-output worksheet lists input parameters. Column B shows baseline input values. Column C shows yellow shaded inputs for scenario/sensitivity values. Columns D through W of the input-output worksheet show **Output results for 2011-2030 in red bold font**, reflecting calculations from other worksheets. Output results are shown after related inputs to allow model users to change inputs and immediately see related changes in outputs. Rows of the input-output worksheet are divided into sections highlighted in green. These sections show inputs to and outputs from related worksheets as illustrated above in Table 2-1. The **summary** worksheet (not shown in Table 2-1) records information from the input-output worksheet and compares 2030 baseline and sensitivity/scenario results in columns E and F. Summary results are also recorded in these columns, in rows 254 through 270, and can be copied and saved in separate worksheets.

2.1 Methodology

The direct impacts model methodology, described in more detail in Section 3, reflects the following basic logic associated with the four sections of the Input-Output worksheet shown in Table 2-1:

- Lube oil sales are a function of vehicle miles traveled, drain cycle intervals, and oil pan capacity.
- Industrial oil sales are a function of 2011 sales by industrial oil segments and forecast growth rates by segment.
- Used oil collection is a function of lube and industrial oil sales and collection rates that are affected by collection incentive payments and used oil prices.
- Product recovery is a function of used oil collected and recovery rates for products that are affected by incentives and fees that change the effective price of recovered products relative to virgin material products that are close substitutes.

This methodology produces lube oil sales forecasts that increase with higher vehicle miles traveled growth rates and/or slower drain cycle growth rates, assuming no change in pan capacity. Industrial oil sales are a straightforward calculation based on growth rate inputs for industrial oil segments.

Price Elasticity of Supply (PEoS) is an important concept reflected in the model's calculation of oil collection, where **PEoS = (Percentage Change in Supply) / (Percentage Change in Price)**. If the PEoS is estimated to be 0.2 for a given product, then a 10 percent increase in the price paid for that product will increase supply by 2 percent. The model applies this concept to used oil collection scenarios by calculating the percentage change in the effective price received by suppliers of:

- Do-It-Yourselfers (DIY) used lube oil
- Non-DIY used lube oil
- Used industrial oil

For non-DIY lube and industrial used oil suppliers, the percentage change in the effective price they receive reflects both the market value of used oil plus any incentive payments for used oil collection. In the case of DIY used oil supply, the model assumes that changes in the market price of used oil are not passed through to individuals recycling DIY used oil, so the percentage change in the effective price they receive reflects only incentive payments for used oil collection.

Cross Elasticity of Supply (CEoS) is an important concept reflected in the model's calculations for recycled products recovered, where **CEoS = (Percentage Change in Q1/Q2) / (Percentage Change in P1/P2)**, Q1 and Q2 are quantities of two inputs used in production, and P1 and P2 are per-unit prices of those inputs. If the CEoS is estimated to be 2.0 for two competing inputs, then a 10 percent increase in the ratio of P1/P2 will result in a 20 percent increase in the ratio of Q1/Q2. The model applies this concept to the recovery of products from used oil by calculating how scenario fees and incentives result in an effective change in the ratio of P1/P2 for pairs of recovered products and virgin materials that compete as inputs for production. Specifically, the model applies this concept to the recovery of the following three pairs of recovered products and competing virgin materials:

- Re-refined base oil versus virgin base oil
- Marine distillate oil/recovered light fuels versus ultra-low sulfur diesel
- Recycled fuel oil and residual fuel oil.

Re-refined base oil clearly substitutes for virgin base oil in lubricant production. The substitution of recovered light fuels for ultra low-sulfur diesel, and recycled fuel oil for residual fuel oil, is a modeling simplification of a more complex market relationship, because marine distillate oil/recovered light fuels and recycled fuel oil are often used as blending fuel with ultra low-sulfur diesel or residual fuel oil. At the margin, however, changes in fees or incentives that reduce the effective price of marine distillate oil/recovered light fuels and recycled fuel oil are expected to create an economic incentive to substitute these recovered fuels for virgin ultra low-sulfur diesel or residual fuel oil, subject to constraints on the supply of used oil available for fuel recovery.

The model's methodology essentially assumes that recovery of re-refined base oil, marine distillate oil/light fuels, and recycled fuel oil in 2013 reflects a market-equilibrium in the competitive substitution of each of these recovered products relative to virgin product counterparts. Fees and incentives that effectively change the ratio of P1/P2 for any of these product pairs in 2014 or beyond result in changes in the ratio of Q1/Q2, based on the model's input for Cross Elasticity of Supply (CEoS). The calculation of scenario impacts on the amount of specific products recovered from used oil also reflects inputs for co-production of light fuels associated with re-refined base oil recovery, and co-production of asphalt flux from marine distillate oil/ light fuels and re-refined base oil recovery.

2.2 Exogenous Market Forces

The substantial rise in crude oil and petroleum product prices over the past decade and the decline in natural gas prices over recent years are important exogenous market trends affecting the California used oil market, and indirectly reflected in the model. The increase in petroleum product prices has been associated with used oil in California going from a negative value that generators had to pay to have used oil hauled away, to a significant positive value in the range of $0.30 per gallon.

Stakeholders have indicated that higher used oil prices have been associated with an increase, and ongoing planned increases, in used oil re-refining capacity outside of California. The material flow analysis data for 2007-2011 reflects this trend with a significant increase over recent years in the percent of California used oil exports that are going to re-refining as opposed to recycled fuel oil production. The model reflects this ongoing trend with estimated increases in the percent of used oil exports going to re-refining in 2012 and 2013. Within California, this trend was delayed by a short-term loss of re-refining capacity, but this capacity is now back on line and can accommodate more demand for re-refined supply.

The decline in natural gas prices has encouraged widespread conversion from petroleum products to natural gas in locations with access to natural gas pipelines. The substitution of natural gas for petroleum in the electric utility industry illustrates the impact of cross-elasticity of supply. The Energy Information Administration has estimated that the CEoS for petroleum versus natural gas use by electric utilities is very close to 2.0,[2] and the large decline in natural gas prices while petroleum prices have remained at comparatively high levels has resulted in a steep decline in both distillate and residual fuel use by electric utilities.

3 Direct Impacts Model Functional Relationships, Key Inputs, and Data Limitations

Functional logic and key inputs connecting each input-output section with related worksheets is described below. This section is organized as follows:

3.1 Lube Oil input-output section and baseline and scenario worksheets

3.2 Industrial Oil input-output section and baseline and scenario worksheets

3.1 Lube Oil input-output section and baseline and scenario worksheets

3.1.1 Vehicle Miles Traveled (VMT)

The lube oil section of the input-output worksheet has baseline and scenario/sensitivity analysis input cells for the average annual growth rates in vehicle miles traveled (VMT) in 2011-2015 and 2015-2030. This design feature allows the model user to specify near-term VMT growth rates that might differ from estimated long term growth rates. The model has separate baseline and scenario inputs for VMT growth rates for four vehicle categories: Auto/Motorcycle; light trucks; single-unit trucks; and combo trucks (tractor-trailers).

The data for 2007-2011 was extracted from the EMFAC Emissions Database and the baseline mileage growth rates for cars, light trucks, and heavy-duty vehicles reflect the database's forecast growth rates for 2011-2015 and for 2015-2030.[3] This growth rate forecast is consistent with recent trends that show a decline in national miles traveled from 2007 through 2012.[4] It has historically declined during recessions and then quickly resumed its long-term growth trend, but the absence of any growth from 2004-2012 spans an unprecedented number of years before and after the recent recession. Part of this new trend is due to telecommuting: The Census Bureau reports that the percentage of people who worked at home at least one day per week increased from 7.0 percent in 1999, to 7.8 percent in 2005, and jumped to 9.5 percent of all workers in 2010, and the percent of the workforce that worked the majority of the week at home rose even faster since 2005, to 4.3 percent of all workers in 2010.[5] The aging U.S. population will also reduce VMT growth because people above age 55 drive fewer miles. A variety of social trends also appear to have substantially reduced miles traveled by drivers ages 16 to 34.[6]

3.1.2 Drain Capacity, Drain Cycle, and Drain Cycle Growth

The mileage growth rates discussed above link to the 2007-2011 miles traveled data in the lube oil baseline and scenario forecast worksheets to calculate the forecast by vehicle category through 2030. This forecast links to inputs for drain capacity, drain cycle, and drain cycle compound annual growth rate. The combined impact of miles traveled growth and drain cycle annual growth inputs determines forecast lube oil sales and impacts associated forecasts for used oil collection and product recovery.

The model's baseline inputs for drain cycle growth rates reflect data on drain cycle intervals over recent years and recent trends in manufacturer recommended oil change intervals. A National Oil and Lube News (NOLN) quick lube operator survey reported average intervals of 4,227 miles in 2005, and 4,520 miles in 2011, reflecting a drain cycle growth rate from 2005-2011 of just over 1 percent per year.[7] The California Integrated Waste Management Board (now CalRecycle) also estimated that an average California oil change interval in 2005 of 4,221 miles.[8] However, the 2011 NOLN survey showed a longer average drain interval of 4,895 miles for vehicles with oil life monitoring systems, and its data are for quick lube drain cycles. Newer vehicles with longer recommended oil change intervals are more likely to have oil changes performed at auto dealerships.

The model was used for sensitivity analysis showing that a 1 percent per year growth in drain cycles, starting with a 6,000 mile average drain cycle in 2011, would result in an average 2030 drain cycle of just 7,249. About two-thirds of vehicle miles traveled is driven by vehicles less than 11 years old,[9] which suggests that average drain cycles in 2030 should be close to or higher than recommended intervals on new vehicles sold today. Table 2-2 shows recommended drain intervals for the Top 10-selling light-duty vehicles in California in 2006 and 2011, with the weighted average recommended interval increasing from 5,981 in 2006 to 7,922 in 2011.

Table 2-2: 2006-2011 Change in Recommended Oil Change Interval for Top 10 Light-Duty Vehicles Sold in California[10]

Sales Rank	2006 Oil Change Interval	2011 Oil Change Interval
1	5,000	7,500
2	5,000	10,000
3	7,500	7,500
4	5,000	5,000
5	7,500	5,000
6	5,000	10,000
7	7,500	7,500
8	7,500	7,500
9	5,000	15,000
10	5,000	7,500
Weighted Average	**5,981**	**7,922**

* Oil Intervals: http://www.checkyournumber.org/;
Sales Data: http://www.cncda.org/secure/GetFile.aspx?ID=2281.

Based on these data, the baseline input for drain cycle growth in the model, reflected in this report, is 2 percent per year from 2011 through 2030. This yields an average light-duty vehicle drain cycle of 8,741 in 2030. This is higher than the 2011 weighted average shown in Table 2-2, consistent with ongoing increases in manufacturer recommended drain cycles in 2012 and 2013 model year light-duty vehicles, and a continuation of this trend is expected in coming years.

The combination of baseline miles traveled and drain cycle growth and drain capacity inputs result in little forecast growth for lube oil sales, consistent with CalRecycle stakeholder comments that market participants generally anticipate lube oil sales that are flat or declining. The model baseline inputs for sump capacity for cars and light trucks also reflect the smaller car and trucks more common in California, and the combination of miles traveled, drain cycle, and drain capacity inputs result in model lube oil sales estimates that are consistent with CalRecycle and Kline data and estimates.

The model's baseline inputs for heavy duty truck drain capacity, drain cycle, and drain cycle annual growth rates are subject to more uncertainty than baseline light-duty vehicle inputs due to the variety of vehicles that could be included in the "single-unit truck" category and variations in operating practices for combo trucks. The single-unit truck category can span commercial pickup trucks, larger delivery trucks, and a variety of "vocational" special purpose vehicles including off-road vehicles. In the case of combo trucks, the drain cycle can be affected by both miles traveled and by engine use to provide cabin power, heat, and air-conditioning during overnight stops. New federal heavy duty vehicle fuel economy and emission regulations are expected to substantially increase use of auxiliary power units (APUs) by long-haul trucks with sleeper cabins, and increased APU use should increase the miles traveled drain cycle for combo trucks. Model baseline inputs for single-unit and combo truck drain capacity and drain cycles reflect rough estimates based on manufacturer product literature and other sources, and drain cycle annual growth rates are assumed to be the same as for light-duty vehicles.

3.1.3 Lube Oil Sales Forecasts

The lube oil baseline and scenario worksheets link the miles traveled forecast by vehicle category with inputs for drain capacity, drain cycle, and drain cycle annual growth rates to calculate passenger car motor oil (PCMO) sales each year. Annual sales for other types of light-duty vehicle lube oil (e.g., gear oil and greases) are estimated as a percent of annual PCMO sales. The model baseline inputs for the percent of PCMO used to estimate other light-duty vehicle lube oil use reflect data provided by Kline.

Lube oil baseline and scenario forecasts also link the heavy duty miles traveled forecast to corresponding inputs for heavy duty drain capacity, drain cycle, and drain cycle annual growth rates to calculate heavy duty motor oil (HDMO) sales each year. Annual sales for other types of heavy duty lube oil are estimated as a percent of HDMO sales. Baseline model inputs for these percentages reflect data and analysis provided by Kline.

The baseline and scenario lube oil sales worksheets show model estimates for 2007-2011 light-duty vehicle and heavy duty lube oil sales, as well as forecast sales through 2030. The 2007-2011 model estimates for these lube oil sales, based on the specified baseline inputs, are close to the comparable Kline estimates for 2007-2011 for “consumer” and “commercial” lube oil sales (Kline estimates in the model are shaded in orange). The 2007-2011 model estimates for total lube oil sales are also close to material flow analysis/CalRecycle reported total lube oil sales. In 2011, CalRecycle reported total lube oil sales are equal to 102 percent of the model’s estimate for total lube oil sales. The last section of the baseline and scenario lube oil sales worksheets apply this 2011 percentage to calculate calibrated lube oil sales forecasts consistent with the 2011 material flow analysis/CalRecycle reported sales. The model calibrated light-duty vehicle and heavy duty lube oil sales forecasts, which are then linked back to the input-output worksheet at the end of the lube oil section.

3.2 Industrial Oil input-output section and baseline and scenario worksheets

The Industrial Oil section of the input-output worksheet allows the model user to enter different annual growth rates for 2011-2015 and 2015-2030 for 14 different types of industrial oil. These categories are a consolidated list of industrial oil segments with California sales estimates and forecasts provided by Kline (the model combines some Kline categories with similar growth and consumption forecasts). The industrial oil baseline and scenario worksheets show 2007-2011 Kline sales estimates for each of these 14 industrial oil segments, and forecast sales through 2030 based on the annual growth rate inputs entered in the industrial oil input-output section. The baseline inputs reflect Kline annual growth rate estimates.

The last two rows of the industrial oil baseline and scenario worksheets show total forecast industrial oil sales through 2030, and compare the Kline-based model estimates with CalRecycle reported industrial oil sales for 2007-2011. The model forecast is based on the Kline estimates because there is reason to believe that the higher CalRecycle reported industrial oil sales include exported product that would not affect the California used oil market. The CalRecycle estimates are shown for comparison with the Kline data, but this is not intended to suggest that a better estimate falls in between these two estimates: The Kline data are subject to a margin of error, plus or minus, but are considered the best available estimates. The model's industrial oil sales data are based on Kline estimates derived from national data scaled down to estimate industrial oil use in California, resulting in a larger potential error, plus or minus, than is the case with lube oil sales.

3.3 Used Oil Collection input-output section and baseline and scenario worksheets

3.3.1 Collectible Used Oil

The first part of the Used Oil Collection section shows inputs for technical and non-technical losses for different lube oil and industrial oil segments. Technical losses (rows 72-99) refer to the percentage of each lube and industrial oil category that is consumed-in-use. Non-technical losses (rows 100-127) refer to used oil that is not "collectible" because it has a more economic legal use, most often as a fuel used onsite. Baseline inputs for technical and non-technical losses reflect Kline estimates, and the model calculates the collectible percent of each lube and industrial oil segment, after subtracting technical and non-technical losses. Kline estimates for non-technical losses are really lower bounds for such losses, largely limited to greases, and Kline has acknowledged considerable uncertainty about the extent to which other types of used oil are now consumed onsite by generators mixing used oil with other fuel to offset the use of some higher priced petroleum product.

One source of considerable uncertainty in this analysis is the water content of used oil collected. Used oil collected in the model is based on lube and industrial oil sales plus adjustments for water content. The baseline inputs assume added water content of 5 percent for lube and 30 percent for industrial oil, based on discussions with stakeholders and the life cycle assessment contractor, but there is acknowledged imprecision associated with these estimates. The model also reflects dewatering associated with product recovery based on material flow analysis results for product recovery as a percent of used oil collected in 2011.

These material flow assessment results vary for products recovered in California versus products recovered from used oil exports, with 2011 California product recovery accounting for 81.2 percent of collected used oil recycled in California versus 90.7 percent for product recovery out of state from used oil exports. The model applies the different 2011 percentages in forecasts for product recovery in California and from used oil exports. However, the model reflects some shift in product recovered in California versus product from used oil exports in some scenarios shown in Section 4, so there is a small estimation error in the model associated with these water content adjustments. This error results in differences of less than 0.1 percent in the total amount of recovered products in scenarios versus total product recovered in the baseline when there is no change in used oil collected. The model results shown in Section 4 also reflect rounding error.

The baseline and scenario collection worksheets multiply the collectible percentages of each lube and industrial oil segment times the corresponding segment sales forecast in the lube and industrial worksheets. This calculates the total collectible used oil amount for each segment, excluding water that is commonly mixed with collected used oil, and shows collectible subtotals for lube oil x-water and industrial oil x-water (on lines 16 and 31). These “x-water” subtotals are not comparable to material flow analysis data for 2007-2011 Lube Oil Collected (line 32) and industrial oil collected (line 40) because the flow analysis amounts for collected used oil include water content. The last row in both the baseline and scenario collection worksheets show the flow analysis estimate for average water content of used oil collected, and the model applies the average for 2007-2011 to 2012 through 2030. The collectible subtotals for lube oil x-water and industrial oil x-water, in 2007-2011 and in the baseline and scenario forecasts to 2030, are adjusted upwards to reflect this estimated water content in collected used oil.

Unfortunately, the flow analysis estimate for water content of used oil does not provide separate estimates for the water content of collectible lube oil versus industrial oil, or for segments of collectible lube oil (Do-It-Yourselfers, other light-duty vehicles, and heavy duty). This introduces an additional source of uncertainty in the forecast for collectible used oil, and the amount of uncollected collectible used oil in each segment.

3.3.2 Used Oil Collection: Incentives, price elasticity, and supply

The second part of the Used Oil Collection section begins with inputs for the Do-It-Yourselfers (DIY) percentage of light-duty vehicle lube oil sales and the uncollected percentage of DIY lube oil. The baseline input for the DIY percentage of light-duty vehicle lube oil sales is 18 percent. This input is consistent with a 2005 California survey[11] that found that 18 percent of respondents either changed their own oil or had a friend or family member do it. The baseline input for the percent of DIY lube oil that is not collected and recycled is 30%. The model calculates the percent of collectible non-DIY lube oil and industrial oil that is not collected, based the inputs for DIY, the total amount of collectible and collected used oil (with water), including non-DIY light-duty vehicle lube oil, heavy duty lube oil, and industrial oil.

Model calculations based on flow analysis data and DIY inputs estimate that 18 percent of collectible non-DIY lube oil is not collected and 43 percent of collectible industrial oil is not collected. It is important to note that these estimates reflect data limitations that could overstate the percent of collectible non-DIY lube oil and industrial oil that is not collected, especially in light of recent trends in the market value of used oil, and the extent of regulatory oversight for non-DIY lube oil collection.

The price of used oil paid to generators will vary due to quantity generated and distance traveled for collection, but CalRecycle stakeholders have generally agreed that used oil generators have received $0.20 to $0.40 per gallon for used oil in recent years, but were paying to have used oil hauled away just a few years earlier. This means market forces have effectively created an incentive of roughly $0.30 per gallon for used oil recycling by non-DIY lube oil and industrial oil generators, making improper management and disposal an irrational economic decision in addition to being a regulatory violation.

In the case of industrial oil, the flow analysis data and other model inputs indicate that the uncollected percent of “collectible oil” *increased* from 18 percent in 2007 to 43 percent in 2011, and the data for 2011 are the basis for the model input that 43 percent of collectible industrial oil is not collected. This trend contradicts the economic logic that an increase in the value of used oil should have increased the industrial oil collection rate. Therefore, analysis of the impact of adding an industrial used oil collection incentive is qualified by the limitations of the available data on collectible industrial oil. This same concern applies to the estimates for uncollected collectible non-DIY lube oil.

The rest of the Collection section of the input-output worksheet includes inputs for price elasticity of supply estimates, used oil prices, and incentive payments for DIY lube oil, non-DIY lube oil, and industrial oil. The collection baseline and scenario worksheets use these inputs to calculate changes in collected used oil, subject to the constraint of collectible used oil, and uncollected collectible used oil.

The baseline input estimates for the price elasticity of supply for used oil collection is 0.2, based on estimates for the response to automotive battery recycling incentives some years ago, and a confidential estimate for used oil recycling elasticity provided to ICF. Unfortunately, the more recent confidential estimate directly related to used oil recycling has not been provided with any extensive documentation, and observed market trends suggest that the California market reaction to price incentives for recycling has been much more muted than the 0.2 elasticity estimate would suggest.

As noted above, the increase in the market price of used oil over recent years should have increased non-DIY lube oil and industrial oil recycling if the price elasticity of supply had the expected impact, but there is no clear evidence of this response in the amount of non-DIY lube oil collected, and flow analysis data show that the percent of collectible industrial oil collected has actually declined considerably over years when used oil prices increased. There is also evidence that up to 95 percent of DIY recyclers do not even collect the 40-cent incentive for DIY collection, and local California program officials have indicated to CalRecycle and ICF that they have not seen any market response to the last increase in the DIY incentive to $0.40 per gallon.

The unexpected lack of market response to higher used oil prices, showing little evidence of any increase in used oil supply, could be explained by other market forces. The expected market impact associated with the price elasticity of supply assumes that all other things equal, but the market forces that caused used oil prices to increase have also affected related markets in ways that could reduce used oil collection. In particular, the increase in used oil prices has been associated with an increase in all petroleum product prices, and this would create a stronger economic incentive for some used oil generators to consume used oil on site as a fuel, thereby reducing virgin petroleum product costs.

In other words, higher fuel prices could increase "non-technical losses" by increasing and the percent of used oil that is not "economically collectible." It is also possible that the seeming lack of supply response to higher used oil prices simply reflects uncertainty about water content adjustments, and other data limitations. In the case of DIY used oil, local California program officials have indicated to CalRecycle and ICF the market has not been sensitive to the increase in the DIY incentive to $0.40 per gallon because DIY generators are more concerned about the speed and convenience of dropping off used oil at a collection location.

In recognition of market response uncertainties described above, scenario analysis in Section 4 related to collection incentives show results with price elasticity of supply estimates of 0.2 and

0.02, where the latter estimate provides a sensitivity analysis indicating the market response if the elasticity of supply is actually much lower than the limited available data on this market suggests.

3.4 Product Recovery input-output section and baseline and scenario worksheets

The product recovery section of the input-output worksheet has baseline and scenario inputs for fees and subsidies for virgin and re-refined lube oil, re-refined production incentive payments, and recovered light fuel and recycled fuel oil. This section also has inputs for the prices of re-refined and virgin base oil, recovered light fuel and ultra low-sulfur diesel, and recycled fuel oil and residual fuel. This section also has inputs for cross elasticity of supply estimates and for in-state re-refined and marine distillate oil/light fuel recovery capacity, and economic export re-refined capacity. All of these capacity inputs refer to the production capacity for that product, not the used oil input capacity.

The inputs described above are linked to the recovery baseline and scenario worksheet to calculate the “unconstrained” quantity demand for each recovered product, based on the fee, subsidy, and cross elasticity of supply inputs. The unconstrained demand is compared to the capacity constraint for that product, and the overall constraint of used oil collected for product recovery. Where the collected used oil constraint applies, the logic in this worksheet assumes that the limited supply of used oil would flow first to re-refining and light fuel recovery, as these are higher value products that entail larger capital investments. Stakeholders have noted that this assumption is not supported by some markets in Europe, where recovered fuel operations can take used oil share from re-refining facilities, but the exogenous market forces in Europe are very different because natural gas is much more expensive in Europe. The higher price of natural gas there, and specifically the price relative to petroleum products, should increase the relative value of recovered light fuel and recycled fuel oil in Europe.

Baseline inputs for asphalt flux output per gallon of re-refined and marine distillate oil/light fuel recovered, and co-product light fuel from re-refined, are from the material flow analysis 2011 data. The baseline input for the cross-elasticity of supply for re-refined versus virgin base oil, recovered light fuel versus ultra low-sulfur diesel, and recycled fuel oil versus residual fuel is based on the Energy Information Administration estimate for the elasticity of supply for petroleum versus natural gas in the electric power industry.[12]

Due to uncertainty associated with elasticity estimates and the range of specific incentives and fees that could be considered by CalRecycle, the scenario analyses in Section 4 describe how a changes in elasticity estimates and specific incentives and fees would affect impacts, based on sensitivity analysis using the DIM. In general, the variation in impacts is proportionate to the change in input values for elasticity estimates and specific incentives and fees.

4 Scenario and Sensitivity Analysis

This section presents 10 policy scenario analyses, including a discussion of sensitivity analysis results and closely related policy options associated with each scenario. This analysis is presented in 10 subsections:

4.1 Scenarios 1 and 1b: Adjust DIY used lube oil recycling incentive payment

4.2 Scenarios 2 and 2b: Adjust non-DIY used lube oil recycling incentive

4.3 Scenarios 3 and 3b: Create used industrial oil recycling incentive

4.4 Scenarios 4 and 4b: Increase the market value of used oil collected in California

4.5 Scenario 5: Adjust differential between manufacturer's fee paid on virgin lube relative to fee paid on lube from re-refined base oil

4.6 Scenario 6: Adjust re-refining incentive

4.7 Scenario 7: Create recovered light fuel/marine distillate oil incentive

4.8 Scenario 8: Create recycled fuel oil incentive

4.9 Scenario 9 (Statutory): Evaluate impacts of tiered fee structure

4.10 Scenarios 10 & 10b (Statutory): Evaluate impacts of tiered incentive payments

The description of each scenario analysis below presents the volume summary data for the baseline and sensitivity/scenario analysis, as reported in the model's Summary Worksheet. The corresponding Summary Worksheet for each sensitivity/scenario analysis is also preserved as a separate worksheet in the model. Results shown for these scenarios reflect rounding error and some model estimation error associated with water content of used oil collected.

4.1 Scenarios 1 and 1b (Sn1 & Sn1b): Adjust Do-It-Yourselfers (DIY) used lube oil recycling incentive

Scenarios 1 and 1b (Sn1 & Sn1b) examine the impacts of doubling the DIY incentive payment from $0.40 per gallon in 2013 to $0.80 per gallon in 2014-2030. The only difference between Scenarios 1 and 1b is that Sn1 assumes a DIY used oil price elasticity of 0.2, whereas Sn1b assumes a DIY used oil price elasticity of 0.02. This means that the market response to any given increase in the DIY incentive in Scenario 1 is 10 times greater than the response in Scenario 1b.

Table 4-1: Impacts of $0.40 per Gallon Increase in DIY Used Lube Oil Incentive to $0.80

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn1	2030 Sn1b
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1	43.1
Industrial Oil Sales	-	124.6	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8	59.8
Lube Oil Collected	**YES**	**77.7**	**79.3**	**77.9**
Industrial Oil Collected	-	34.0	34.0	34.0
Uncollected Collectible DIY Lube Oil	**YES**	**3.4**	**1.8**	**3.3**

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn1	2030 Sn1b
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**15.1**	**14.1**
Re-Refined Oil Recovered	-	21.3	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2	43.2
Asphalt Flux Recovered	-	25.4	25.4	25.4
Recycled Fuel Oil Recovered	**YES**	**2.1**	**3.5**	**2.2**
Total Recovered Product	**YES**	**92.1**	**93.5**	**92.2**

Table 4-1 shows that a $0.40 per gallon increase in the DIY incentive payment:

- Increases 2030 used lube oil collected by 1.6 million gallons, to 79.3 million in Sn1, from 77.7 million gallons in the baseline. Sn1b increases lube oil collected by 160,000 gallons (values in Table 4-1 reflect rounding error), which is one-tenth of the impact under Sn1.
- Decreases 2030 uncollected collectible DIY lube oil by 1.6 million gallons in Sn1, and by 160,000 gallons in Sn1b.
- Does not change the forecasts for 2030 uncollected collectible non-DIY lube oil or industrial oil because the DIY incentive does not affect the supply of non-DIY used oil.
- Does not change the forecasts for 2030 recovered re-refined, light fuels, or asphalt flux because the increase in used oil collected does not affect the market equilibrium for these recovered products versus virgin products.
- Increases recycled fuel oil by approximately 1.4 million gallons in Sn1 and 140,000 gallons in Sn1b.

The proportionate relationship between the price elasticity inputs for Sn1 and Sn1b and the corresponding impacts of a $0.40 per gallon increase in the DIY incentive also apply across a range of price elasticity inputs for this scenario. For example, a sensitivity analysis with the DIM shows that a DIY price elasticity input of 0.1 (half the price elasticity input for Sn1) results in an 800,000 gallon increase in lube oil collected and an 800,000 gallon decrease in uncollected collectible DIY lube oil (half of the impacts for Sn1). Similarly, a DIY price elasticity input of 0.4 (twice the price elasticity input for Sn1) results in a 3.2 million increase in lube oil collected and a 3.2 million decrease in uncollected collectible DIY lube oil (twice the impacts for Sn1). However, a DIY price elasticity input of 0.43 or higher only increases lube oil collected by 3.4 million gallons because the market response is constrained by the baseline forecast for 3.4 million gallons of uncollected collectible DIY lube oil in 2030.

Sensitivity analysis also shows that there is a similar proportionate response to the change in the DIY incentive. For example, if the price elasticity input is 0.2 (as it is for Sn1) but the DIY incentive is increased by $0.20 per gallon (half the incentive increase in Sn1) to $0.60, then the increase in lube oil collected and decrease in uncollected collectible DIY lube oil is 800,000 gallons (half of the impacts for Sn1). Similarly, if the price elasticity input is 0.2 but the DIY incentive is increased by $0.80 per gallon (twice the incentive increase in Sn1) to $1.20, then the increase in lube oil collected and decrease in uncollected collectible DIY lube oil is 3.2 million (twice of the impacts for Sn1). However, if the price elasticity is 0.2 and the DIY incentive is $1.30 or higher, then lube oil collected only increases by 3.4 million gallons because the market response is constrained by the baseline forecast for 3.4 million gallons of uncollected collectible DIY lube oil in 2030.

4.2 Scenarios 2 and 2b (Sn2 & Sn2b): Adjust non-DIY used lube oil recycling incentive

Scenarios 2 and 2b (Sn2 & Sn2b) examine the impacts of increasing the non-DIY used lube oil incentive payment from $0.16 per gallon in 2013 to $0.56 per gallon in 2014-2030, an increase of $0.40. The only difference between Scenarios 2 and 2b is that Sn2 assumes a non-DIY used oil price elasticity of 0.2, whereas Sn2b assumes a price elasticity of 0.02. Therefore, the market response to any given increase in the non-DIY lube oil incentive in Scenario 2 is 10 times greater than the response in Scenario 2b.

Table 4-2 shows that a $0.40 per gallon increase in the non-DIY used lube oil incentive payment:

- Increases 2030 used lube oil collected by 12.1 million gallons to 89.8 million gallons in Sn2, from 77.7 million in the baseline; Sn2b increases lube oil collected by 1.2 million gallons (one-tenth of the impact under Sn2).
- Decreases 2030 uncollected collectible non-DIY lube oil by 12.1 million gallons in Sn2, and by 1.2 million gallons in Sn2b.
- Does not change the forecasts for 2030 uncollected collectible DIY lube oil or industrial oil because the non-DIY incentive only affects the supply of non-DIY used lube oil.
- Does not change the forecasts for 2030 recovered re-refined, light fuels, or asphalt flux because the increase in used oil collected does not affect the market equilibrium for these recovered products versus virgin products.
- Increases recycled fuel oil by approximately 10 million gallons in Sn2 and 1 million gallons in Sn2b (Table 4-2 reflects rounding error and some model estimation error associated with the water content of used oil collected).

Table 4-2: Impacts of $0.40 per Gallon Increase in Non-DIY Used Lube Oil Incentive to $0.56

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn2	2030 Sn2b
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1	43.1
Industrial Oil Sales	-	124.6	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6	63.6

Collectible Heavy Duty Lube Oil	-	32.6	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8	59.8
Lube Oil Collected	**YES**	**77.7**	**89.8**	**78.9**
Industrial Oil Collected	-	34.0	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	**YES**	**15.1**	**3.0**	**13.9**
Uncollected Collectible Industrial Oil	-	25.8	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**16.5**	**15.0**
Re-Refined Oil Recovered	-	21.3	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2	43.2
Asphalt Flux Recovered	-	25.4	25.4	25.4
Recycled Fuel Oil Recovered	**YES**	**2.1**	**12.2**	**3.2**
Total Recovered Product	**YES**	**92.1**	**102.1**	**93.1**

The proportionate relationship between the price elasticity inputs for Sn2 and Sn2b and the corresponding impacts of a $0.40 per gallon increase in the non-DIY incentive also apply across a range of price elasticity inputs for this scenario. For example, a sensitivity analysis shows that a non-DIY price elasticity input of 0.1 (half the price elasticity input for Sn2) results in a 6 million gallons increase in lube oil collected and a 6 million gallons decrease in uncollected collectible non-DIY lube oil (half of the impacts for Sn2). A non-DIY price elasticity input of 0.25 or higher only increases lube oil collected by 15.1 million gallons because the market response is constrained by the baseline forecast for 15.1 million gallons of uncollected collectible non-DIY lube oil in 2030.

Sensitivity analysis shows a similar proportionate response to changes in the non-DIY incentive. If the price elasticity input is 0.2 (as it is for Sn2) but the non-DIY incentive is increased by $0.20 per gallon (half the increase in Sn2) to $0.36, then the increase in lube oil collected and decrease in uncollected collectible non-DIY lube oil is about 6 million gallons (half of the impacts for Sn2). If the price elasticity is 0.2 and the non-DIY incentive is increased by $0.50 per gallon or more, to $0.66 or higher, then lube oil collected increases by 15.1 million gallons because the market response is constrained by the baseline forecast for 15.1 million gallons of uncollected collectible non-DIY lube oil in 2030.

4.3 Scenarios 3 and 3b (Sn3 & Sn3b): Create used industrial oil recycling incentive

Scenarios 3 and 3b (Sn3 & Sn3b) examine the impacts of creating a used industrial oil incentive of $0.40 per gallon in 2014-2030. The difference between Scenarios 3 and 3b is that Sn2 assumes a used industrial oil price elasticity of 0.2, whereas Sn2b assumes an elasticity of 0.02. Therefore, the market response to this incentive in Scenario 3 is 10 times the response in Scenario 3b.

Table 4-3: Impacts of Creating $0.40 per Gallon Used Industrial Oil Incentive

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn3	2030 Sn3b
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1	43.1
Industrial Oil Sales	-	124.6	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8	59.8
Lube Oil Collected	-	77.7	77.7	77.7
Industrial Oil Collected	**YES**	**34.0**	**43.1**	**34.9**
Uncollected Collectible DIY Lube Oil	-	3.4	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1	15.1
Uncollected Collectible Industrial Oil	**YES**	**25.8**	**16.7**	**24.9**
Used Oil Exports	**YES**	**14.0**	**16.1**	**14.8**
Re-Refined Oil Recovered	-	21.3	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2	43.2
Asphalt Flux Recovered	-	25.4	25.4	25.4
Recycled Fuel Oil Recovered	**YES**	**2.1**	**9.7**	**2.9**
Total Recovered Product	**YES**	**92.1**	**99.6**	**92.9**

Table 4-3 shows that a $0.40 per gallon used industrial oil incentive payment:

- Increases 2030 used industrial oil collected by 9.1 million gallons to 43.1 million gallons in Sn3, from 34.0 million gallons in the baseline; Sn3b increases industrial oil collected by 900,000 gallons (one-tenth of the impact under Sn3).
- Decreases 2030 uncollected collectible industrial oil by 9.1 million gallons in Sn3, and by 900,000 gallons in Sn3b.
- Does not change the forecasts for 2030 uncollected collectible lube oil because the new industrial oil incentive does not affect the supply of used lube oil.
- Does not change the forecasts for 2030 recovered re-refined, light fuels, or asphalt flux because the increase in used oil collected does not affect the market equilibrium for these recovered products versus virgin products.
- Increases recycled fuel oil by 7.6 million gallons in Sn3 and 800,000 gallons (rounded) in Sn3b.

A used industrial oil price elasticity input of 0.1 — half the price elasticity input for Sn3 — results in an increase in industrial oil collected and decrease in uncollected collectible industrial oil that is half of the impacts shown for Sn3. A used industrial oil price elasticity input of 0.57 or higher increases industrial oil collected by 25.8 million gallons because the market is constrained by the baseline forecast for 25.8 million gallons of uncollected collectible industrial oil in 2030.

Sensitivity analysis shows a similar proportionate response to changes in the magnitude of the new industrial oil incentive. If the price elasticity input is 0.2 (as it is for Sn3) but the industrial oil incentive is increased by $0.20 — half the increase in Sn2 — then the increase in industrial oil collected and decrease in uncollected collectible industrial oil is half of the impacts for Sn3. If the price elasticity is 0.2 and the industrial oil incentive $1.15 per gallon or more, then used industrial oil collected increases by 25.8 million gallons because the market response is constrained by the baseline forecast for 25.8 million gallons of uncollected collectible industrial oil in 2030.

4.4 Scenarios 4 and 4b (Sn4 & Sn4b): Increase the market value of used lube and industrial oil collected in California

Scenarios 4 and 4b (Sn4 & Sn4b) examine the impacts of an increase of $0.40 per gallon in the market value of California used oil, from $0.30 in 2013 to $0.70 in 2014-2030. The difference between Scenarios 4 and 4b is that Sn4 assumes a non-DIY lube oil and industrial oil price elasticity of 0.2, whereas Sn4b assumes an elasticity of 0.02. It is beyond the scope of this analysis to determine what policy actions could achieve this increase in market price, but the impacts are presented here to address stakeholder comments that California used oil prices are much lower than in other states, due to competition constraints, regulatory costs, and/or other factors.

Table 4-4 shows that an increase of $0.40 in the market value of used oil in California:

- Increases 2030 used lube oil collected by 12.1 million gallons and increases industrial oil collected by 9.1 million gallons in Sn4; Sn4b increases lube oil collected by 1.2 million gallons and increases industrial oil collected by 900,000 gallons (one-tenth of the impact under Sn4).
- Decreases 2030 uncollected collectible lube oil by 12.1 million gallons in Sn4 and by 1.2 million in Sn4b, and decreases uncollected collectible industrial oil by 9.1 million gallons in Sn4, and by 900,000 gallons in Sn4b.
- Does not change the forecasts for 2030 uncollected collectible DIY oil because the model assumes that the DIY segment is not sensitive to changes in the market value of used oil because this change in market value is not realized by DIY consumers.
- Does not change the forecasts for 2030 recovered re-refined, light fuels, or asphalt flux because the increase in used oil collected does not affect the market equilibrium for these recovered products versus virgin products.
- Increases recycled fuel oil by 17.6 million gallons in Sn4 and 1.8 million gallons (rounded) in Sn4b.

Table 4-4: Impacts of $0.40 per Gallon Increase in Used Oil Market Value to $0.70

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn4	2030 Sn4b
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1	43.1
Industrial Oil Sales	-	124.6	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8	59.8
Lube Oil Collected	**YES**	**77.7**	**89.8**	**78.9**
Industrial Oil Collected	**YES**	**34.0**	**43.1**	**34.9**
Uncollected Collectible DIY Lube Oil	-	3.4	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	**YES**	**15.1**	**3.0**	**13.9**
Uncollected Collectible Industrial Oil	**YES**	**25.8**	**16.7**	**24.9**
Used Oil Exports	**YES**	**14.0**	**17.7**	**15.1**
Re-Refined Oil Recovered	-	21.3	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2	43.2
Asphalt Flux Recovered	-	25.4	25.4	25.4
Recycled Fuel Oil Recovered	**YES**	**2.1**	**19.7**	**3.9**
Total Recovered Product	**YES**	**92.1**	**109.6**	**93.9**

The impacts shown in Table 4-4 are the same as the impacts shown in Table 4-2 plus those shown in Table 4-3, because the model assumes that a $0.40 per gallon increase in the market value of used oil creates the same used oil supply incentives for non-DIY lube oil recyclers and industrial oil recyclers as a $0.40 per gallon increase in incentive payments. The model's workbook illustrates this fact by including separate worksheets for Sn2&3 and Sn2b&3b scenarios that combine the $0.40 per gallon incentives in these scenarios, and the resulting impacts are the same as for Sn4 and Sn4b.

A price elasticity input of 0.1 — half the elasticity input for Sn4 — results in an increase in lube and industrial oil collected and decrease in uncollected collectible non-DIY lube and industrial oil that is half of the impacts shown for Sn3. Sensitivity analysis shows a similar proportionate response to changes in the magnitude of the change in used oil prices: If the price elasticity input is 0.2 (as in Sn4) but used oil prices increase by $0.20 per gallon — half the increase in Sn2 — then the increase in non-DIY lube oil and industrial oil collected and decrease in uncollected collectible non-DIY lube oil and industrial oil is half of the impacts shown for Sn4.

4.5 Scenario 5 (Sn5): Adjust differential between fee paid on virgin lube relative to fee paid on lube from re-refined base oil

Scenario 5 (Sn5) examines the impacts of $0.10 per gallon decrease in the fee for lube oil from re-refined, from $0.12 in 2013 to $0.02 in 2014-2030, with no change in the $0.24 fee for lube oil from virgin base oil.

Table 4-5: Impacts of $0.10 per Gallon Decrease in Fee for Lube Oil from Re-Refined to $0.02

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn5
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1
HD Lube Oil Sales	-	43.1	43.1
Industrial Oil Sales	-	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8
Lube Oil Collected	-	77.7	77.7
Industrial Oil Collected	-	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**13.1**
Re-Refined Oil Recovered	**YES**	**21.3**	**22.5**
Marine Distillate Oil/Light Fuels Recovered	**YES**	**43.2**	**43.0**
Asphalt Flux Recovered	**YES**	**25.4**	**25.5**
Recycled Fuel Oil Recovered	**YES**	**2.1**	**1.0**
Total Recovered Product	**YES**	**92.1**	**92.0**

Table 4-5 shows that this $0.10 per gallon decrease in the fee for lube oil from re-refined:

- Has no impact on the amount of collected or uncollected used oil.
- Increases 2030 re-refined base oil by 1.2 million gallons, to 22.5 million gallons from 21.3 million gallons in the baseline.
- Decreases 2030 marine distillate oil/light fuels recovered by 200,000 gallons.
- Increases 2030 asphalt flux recovered by 100,000 gallons.
- Decreases 2030 recycled fuel oil by 1.1 million gallons.

The impacts shown in Table 4-5 result from the change in the differential between the fees on lube from re-refined versus virgin base oil. Therefore, the same impacts result from a scenario that does not change the fee on lube from re-refined but increases the fee on lube from virgin base oil by $0.10 per gallon (to $0.34 in 2014-2030).

A cross-elasticity input that is half the elasticity for Sn5 results in recovered product impacts that are about half of the impacts shown for Sn5. Sensitivity analysis shows a similar proportionate response to changes in the magnitude of the change in the differential between fees on lube from re-refined versus virgin base oil: If the fee on lube from re-refined is decreased by $0.05 per gallon or the fee on lube from lube from virgin base oil is increased by $0.05 per gallon, then resulting impacts are half of those shown for Sn5.

4.6 Scenario 6 (Sn6): Adjust re-refining incentive

Scenario 6 (Sn6) examines the impacts of $0.10 per gallon increase in the incentive for re-refined base oil, from $0.02 in 2013 to $0.12 in 2014-2030.

Table 4-6: Impacts of $0.10 per Gallon Increase in Re-Refined Incentive to $0.12

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn6
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1
Industrial Oil Sales	-	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8
Lube Oil Collected	-	77.7	77.7
Industrial Oil Collected	-	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**13.1**
Re-Refined Oil Recovered	**YES**	**21.3**	**22.2**
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2
Asphalt Flux Recovered	**YES**	**25.4**	**25.5**
Recycled Fuel Oil Recovered	**YES**	**2.1**	**1.0**
Total Recovered Product	**YES**	**92.1**	**92.0**

Table 4-6 shows that this $0.10 per gallon increase in the incentive for re-refined:

- Has no impact on the amount of collected or uncollected used oil.

- Increases 2030 re-refined base oil by 900,000 gallons, to 22.2 million gallons from 21.3 million gallon sin the baseline.
- Increases 2030 asphalt flux recovered by 100,000 gallons.
- Decreases 2030 recycled fuel oil by 1.1 million gallons.

Impacts under Sn6 are similar to those in Sn5, except that the increase in Sn6 re-refined, and corresponding declines in other recovered products, are about 20 percent less than impacts in Sn5. This reflects the fact that a $0.10 change in the re-refined incentive in Sn6 applies only to base oil recovered, whereas a $0.10 per gallon re-refined lube oil fee reduction in Sn5 applies to re-refined lube oil, and the model’s inputs include an estimate that lube oil is 80 percent base oil and 20 percent additives.

A cross-elasticity input that is half the elasticity for Sn6 results in recovered product impacts that are about half of the impacts shown for Sn6. Sensitivity analysis shows a similar proportionate response to changes in the incentive for re-refined base oil: If the incentive for re-refined base oil is increased by $0.05 per gallon, then resulting impacts are about half of those shown for Sn5.

4.7 Scenario 7 (Sn7): Create recovered light fuel/MDO incentive

Scenario 7 (Sn7) examines impacts of creating $0.10 per gallon recovered light fuel/marine distillate oil incentive in 2014-2030. Table 4-7 shows that this $0.02 incentive for recovered light fuel:

- Has no impact on the amount of collected or uncollected used oil.
- Has no impact on the amount of re-refined base oil because this light fuel incentive does not affect the market equilibrium for re-refined versus virgin base oil.
- Increases 2030 MDO/light fuels recovered by 400,000 gallons, to 43.6 million from 43.2 million in the baseline.
- Increases 2030 asphalt flux recovered by 200,000 gallons.
- Decreases 2030 recycled fuel oil by 700,000 gallons (rounded).

The impacts shown in Table 4-7 result from the change in the differential between the effective cost of recovered light fuel (reduced by the incentive) versus virgin ultra low-sulfur diesel. Therefore, the same impacts result from a scenario that does not create an incentive for recovered light fuel but does impose a $0.10 fee on ultra low-sulfur diesel (in 2014-2030). Impacts in Table 4-7 also reflect constraints on the 2030 increase in recovered light fuels associated with the capacity for marine distillate oil/light fuel recovery in California. The potential increase in recovered light fuels is also constrained by the 2030 baseline forecast for a relatively small amount of recycled fuel oil from California used oil, because the model anticipates that used oil going to recycled fuel oil can be diverted to recovered light fuel/marine distillate oil production only up to the point where light fuel recovery is constrained by the supply of used oil.

Table 4-7: Impacts of Creating $0.10 per Gallon Incentive for Recovered Light Fuel/Marine Distillate Oil

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn7
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1
Industrial Oil Sales	-	124.6	124.6
Collectible Light-Duty Lube Oil	-	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8
Lube Oil Collected	-	77.7	77.7
Industrial Oil Collected	-	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**13.2**
Re-Refined Oil Recovered	-	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	**YES**	**43.2**	**43.6**
Asphalt Flux Recovered	**YES**	**25.4**	**25.6**
Recycled Fuel Oil Recovered	**YES**	**2.1**	**1.4**
Total Recovered Product	**YES**	**92.1**	**92.0**

4.8 Scenario 8 (Sn8): Create recycled fuel oil (RFO) incentive

Scenario 8 (Sn8) shows DIM outputs for creating a $0.10 per gallon incentive for recycled fuel oil production. This scenario does not change any outputs because this recycled fuel oil incentive does not affect the market equilibrium for re-refined versus virgin base oil or recovered light fuel/marine distillate oil versus ultra low-sulfur diesel. This means that recycled fuel oil production is constrained by the amount of used oil collected.

Table 4-8: Impacts of Creating $0.10 per Gallon Incentive for Recycled Fuel Oil

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn8
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1
Industrial Oil Sales	-	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8
Lube Oil Collected	-	77.7	77.7
Industrial Oil Collected	-	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8
Used Oil Exports	-	14.0	14.0
Re-Refined Oil Recovered	-	21.3	21.3
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2
Asphalt Flux Recovered	-	25.4	25.4
Recycled Fuel Oil Recovered	-	2.1	2.1
Total Recovered Product	-	92.1	92.1

4.9 Scenario 9 (Statutory – Sn9): Impacts of tiered fee structure

Scenario 9 (Sn9) addresses the statutory requirement to evaluate the impacts of the tiered fee structure for lube oil sales. Table 4-9 shows that reversing this tiered fee structure by reducing the fee on virgin base lube oil to $0.16 per gallon and increasing the fee on re-refined base lube to $0.16 per gallon (in 2014-2030):

- Has no impact on the amount of collected or uncollected used oil.
- Decreases 2030 re-refined base oil by 1.1 million gallons (rounded).
- Decreases 2030 asphalt flux recovered by 100,000 gallons.
- Increases 2030 recycled fuel oil by 1.3 million gallons (rounded).

In a sense, this scenario is a variation of Scenario 5, adjusting the differential between the fees on lube from re-refined versus virgin base oil. In Sn9, the elimination of both fees results in less re-refined recovered because the differential created by the tiered fee structure is eliminated.

Table 4-9: Impacts of Restoring $0.16 per Gallon Fee for Re-Refined and Virgin Lube Oil

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn9
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1
Industrial Oil Sales	-	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8
Lube Oil Collected	-	77.7	77.7
Industrial Oil Collected	-	34.0	34.0
Uncollected Collectible DIY Lube Oil	-	3.4	3.4
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**14.8**
Re-Refined Oil Recovered	**YES**	**21.3**	**20.3**
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2
Asphalt Flux Recovered	**YES**	**25.4**	**25.3**
Recycled Fuel Oil Recovered	**YES**	**2.1**	**3.4**
Total Recovered Product	**YES**	**92.1**	**92.1**

4.10 Scenarios 10 and 10b (Statutory – Sn10 & Sn10b): Impacts of tiered incentive structure

Scenarios 10 and 10b (Sn10 & Sn10b) address the statutory requirement to evaluate impacts of the tiered incentive structure for lube oil collection and re-refined base oil recovery. The difference between Scenarios 10 and 10b is that Sn10 assumes a lube oil price elasticity of 0.2, whereas Sn10b assumes an elasticity of 0.02. Table 4-10 shows that reversing the tiered incentive system by reducing the DIY used lube oil incentive to $016 incentive and eliminating the $0.02 incentive for re-refined base oil recovery:

- Decreases 2030 lube oil collected by one million gallons, to 76.7 million gallons in Sn10, from 77.7 million gallons in the baseline. Sn10b decreases lube oil collected by 100,000 gallons, reflecting the elasticity input for Sn10b that is one-tenth of the elasticity input for Sn10.
- Increases 2030 uncollected collectible DIY lube oil by 1 million gallons in Sn10, and by 100,000 gallons in Sn10b.
- Decreases 2030 re-refined by 100,000 gallons, from 21.3 million gallons in the baseline to 21.2 million gallons in both Sn10 and Sn10b. (Eliminating the re-refined incentive has the

same re-refined impact in Sn10 and Sn10b because the cross-elasticity for re-refined versus virgin base oil is same in both Sn10 and Sn10b.)

- Increases RFO in Sn10b, reflecting more used oil going to recycled fuel oil due to the decrease in re-refining, but decreases recycled fuel oil in Sn10 due to the larger decrease in used oil collection under Sn10.

Table 4-10: Impacts of Restoring $0.16 per Gallon Incentive for DIY Used Lube Oil and Eliminating $0.02 per Gallon Incentive for Re-Refined

Volume Summary - Million Gallons per Year	Baseline vs. Scenario Change	2030 Baseline	2030 Sn10	2030 Sn10b
Light-Duty Vehicle Lube Oil Sales	-	67.1	67.1	67.1
Heavy Duty Lube Oil Sales	-	43.1	43.1	43.1
Industrial oil sales	-	124.6	124.6	124.6
Collectible Light-Duty Vehicle Lube Oil	-	63.6	63.6	63.6
Collectible Heavy Duty Lube Oil	-	32.6	32.6	32.6
Collectible Industrial Oil	-	59.8	59.8	59.8
Lube Oil Collected	**YES**	**77.7**	**76.7**	**77.6**
Industrial Oil Collected	-	34.0	34.0	34.0
Uncollected Collectible DIY Lube Oil	**YES**	**3.4**	**4.4**	**3.5**
Uncollected Collectible Non-DIY Lube Oil	-	15.1	15.1	15.1
Uncollected Collectible Industrial Oil	-	25.8	25.8	25.8
Used Oil Exports	**YES**	**14.0**	**13.3**	**14.1**
Re-Refined Oil Recovered	**YES**	**21.3**	**21.2**	**21.2**
Marine Distillate Oil/Light Fuels Recovered	-	43.2	43.2	43.2
Asphalt Flux Recovered	**YES**	**25.4**	**25.4**	**25.4**
Recycled Fuel Oil Recovered	**YES**	**2.1**	**1.4**	**2.2**
Total Recovered Product	**YES**	**92.1**	**91.2**	**92.0**

Appendix A

This Excel spreadsheet (MS Excel 1.48 MB) is the Direct Impact Model that was created in support of the Used Oil Life Cycle Assessment Project that was conducted by CalRecycle pursuant to Senate Bill 546 (SB 546, Lowenthal 2009).

This model provides the underlying data and economic relationships between the affected entities in the California used oil management system as well as the results of the analysis for the 20-year baseline condition and a number of hypothetical policy scenarios.

This Excel spreadsheet allows the user to continue to assess how policy changes may affect the California used oil management system.

This spreadsheet is not included in the document but can be downloaded from the CalRecycle website.

[1] The baseline and scenario results in this report are saved in separate worksheets in the 7-25-2013 v5 model.

[2] EIA, at http://www.eia.gov/analysis/studies/fuelelasticities/pdf/eia-fuelelasticities.pdf

[3] California Air Resources Board, at http://www.arb.ca.gov/emfac/. This vehicle miles traveled forecast is lower than the forecast reflected in earlier versions of the model, which were based on Caltrans data that are no longer being updated. The EMFAC data also include categories for heavy-duty agricultural and construction vehicles that were excluded from the Caltrans data. Therefore, this change in vehicle miles traveled data sources avoids the need for separate estimates for off-road vehicles reflected in earlier versions of the model.

[4] http://www.fhwa.dot.gov/policyinformation/travel_monitoring/12dectvt/12dectvt.pdf.

[5] http://www.census.gov/newsroom/releases/archives/employment_occupations/cb12-188.html

[6] http://www.uspirg.org/reports/usp/transportation-and-new-generation

[7] http://www.noln.net/features/feature3-1_1111.php

[8] http://www.calrecycle.ca.gov/publications/Documents/UsedOil%5C61107003.pdf

[9] Tables 3.8 and 3.9 at http://cta.ornl.gov/data/chapter3.shtml

[10] Oil Intervals: http://www.checkyournumber.org/; Sales Data: http://www.cncda.org/secure/GetFile.aspx?ID=2281; http://www.cncda.org/public/California_Auto_Outlook_Market_Reports/California_Auto_Outlook_Fourth_Quarter_2006.pdf

[11] http://www.calrecycle.ca.gov/publications/Documents/UsedOil%5C61107003.pdf

[12] http://www.eia.gov/analysis/studies/fuelelasticities/