Used Oil Life Cycle Analysis (LCAn)
Project Outline

OBJECTIVE

Develop and apply a modeling tool to assess the management of used lubricating oils from an environmental, resource impact, and economic perspective. This model and application will take into account the full life cycle of lubricating oils and products that they may displace, local conditions, and the impacts of varying policy and regulatory frameworks.

MODEL DEVELOPMENT PHASE

The model will be flexible, comprehensive, robust, unbiased, transparent (for both modeling tools and data), and will yield reproducible results.

The model will systematically quantify a number of aspects and impacts, including:

- greenhouse gas and other emissions;
- ground/surface water contamination from leaks during use and improper disposal;
- crude oil and other net resource effects;
- economic feasibility/impacts.
- policy/regulatory framework effects

Two vital principles for the model will be balancing:

1. mass and energy flows into and out of the system; and
2. constant lubricant and energy product production.

The model will consist of a series of modules, for example covering different end uses of used oils. Each module will be transparent so that performance data are accessible and can be updated or extended as new information or processes became available, or tailored to an individual plant or process rather than a generic process. The user will be able to configure the modules to address specific questions and to reflect different aspects of the lubricating oil life cycles (e.g., to test the effects of restricting the choice of outlets for used lubricating oil as affected by regulatory frameworks and market conditions).

The scope of the model will be broad enough to reflect the multiple sources, treatments, and utilization of used oils while also taking into account improper disposal and leakage during use.

The output and application of the model will avoid a simple comparative analysis focus but will provide study team members a comprehensive assessment of the various aspects of the life cycle of lubricating oils.

APPLICATION PHASE

In each application the questions to be addressed will be developed and the model configuration designed to address these (within the context and constrained as appropriate to reflect the complexity of the relevant used oil collection and management industry – i.e. ensuring that the full life cycle is considered and the management of all elements of the used oil stream are accounted for). The necessary data, if not already incorporated in the model, will be sourced, validated and used in model application.

The modules will be transparent in operating on data, and the data collection and sources are envisioned as equally transparent. Potential sources of data are included in the supporting information section.

Scenarios intended to particularly address five aspects of interest to California will be included in the initial application of the model:

- effects of lubricating oil change interval adjustments;
- effects of lubricating oil spills and leaks;
- effects on used oil collection rates - and improper disposal; and
- effects of used oil re-refining, combustion for energy recovery, other recycling and re-use options, and disposal;
- effects of marketplace and regulatory frameworks, e.g., subsidies, disposition priorities, etc.

Analyses

Model development, application, conclusions and documentation of results will be undertaken by third-parties conversant in life cycle applications, and reflect input from the advisory team noted below.

A concurrent ISO review will be conducted by another independent group to verify that the study meets ISO standards relevant to the use of life cycle assessment.

ADVISORY TEAM

The study would be developed with the advice of a project team representative of multiple stakeholder groups including, but not limited to:

Academia
American Petroleum Institute
California environmental agencies, for example
- Cal Recycle
- Department of Toxic Substances Control
- California Air Resources Board,
- State Water Resources Control Board

Non-Governmental Organizations, for example
- American Center for Lifecycle Assessment,
- Product Stewardship Institute,
- Rocky Mountain Institute

NORA, An Association of Responsible Recyclers - representing the following industry sectors:
- lubricant oil manufacturers,
- used oil collection/recycling companies,
- re-refiners,
- industrial burners/fuel use companies,

State and federal regulatory agencies.

SUPPORTING INFORMATION

The modules would be developed to ensure that the full life cycle impacts of changes to used lubricating oil collection and use could be assessed. In this way effects on used lubricating oil collection, effects of displaced materials (e.g., base lube or fuel) will be included and the model will have the flexibility to provide robust assessments of the comparative life cycle effects of different used lubricating oil management scenarios. This will avoid focus only on narrow and likely unrealistic questions such as which of two options for one element of the used oil stream, considered in isolation, represents the best and highest environmental option for used oil treatment (but takes no account of consequences elsewhere in the life cycle).

The study would consider all elements of the used lubricating oil stream (noting that some treatment options would not be appropriate for some elements of the used oil stream but that these would still require management – e.g., some specialty oils not suited to re-refining to base oil).

The model will be able to address:

- production of base oil/lubricants derived from used oil, and production of fuel products derived from crude oil/natural gas;
- production of fuel products derived from used oil, and production of base oil/lubricants derived from crude oil;
- various treatments for recycling/reprocessing used oils;
- various fuel uses, including cement kilns, power plants and asphalt production using appropriate pollution control, and space heaters
- various lubricant uses, such as passenger car motor oils, heavy-duty engine oils, hydraulic oils, and metalworking fluids;
- generation rates for used lubricating oils, e.g., as affected by longer lasting oils
- collection systems for generated used oils.
- impact of leakage and inappropriate disposal of used lubricating oils
- potential impacts related to oil formulation and use – for example extended drain intervals and different oil formulations. Such changes could impact on emissions from vehicles, used oil generation rates (reduced), changed processing impacts, impacts of in use and post use oil spills and leaks as drain interval increases. This element may require linking to elements of LCA that address impacts on vehicle use e.g. fuel economy effects.

See attached Earth 911 Used Oil Management Diagram for an indication of the elements of the used oil life cycle.

Scenarios

Two fundamental scenarios in the application of the model relate to the raw material acquisition module and production modules within the system boundaries. (See ISO 14049, Figure 9- System Environment diagram for an illustration of the concept of balancing to identical products, in that case plastic and heat. In the case of used oil it would likely be constant lubricant and energy products.)

(1) Production of base oil/lubricants derived from used oil, and production of fuel products derived from crude oil/natural gas

(2) Production of fuel products derived from used oil, and production of base oil/lubricants derived from crude oil

		Product	
		Lubricating Oil	Fuel Product
Raw Material	Used Oil	Scenario (I)	Scenario (2)
	Crude or Natural Gas	Scenario (2)	Scenario (I)

In each of the two scenarios, a combination of used oil recycling operations and crude oil refining operations makes the same amounts of equivalent quality base oil for lubricating oil, and heating value in fuel products. In Scenario (1), the used oil is recycled by re-refining it into base oil for lubricating oil, while crude oil refining and/or natural gas is used to provide the fuel product heating value. In Scenario (2), crude oil refining and/or natural gas is used to provide the equivalent quality base oil for lubricating oil in the same volume as Scenario (1), and used oil is recycled into the fuel product heating value equivalent to that in Scenario (1). One can then compare the resource demands and other environmental impacts of Scenarios (1) and (2),

For example, a fundamental underpinning could be that each scenario will produce 10 units of lubricating oil, and 90 units of fuel product -- involving 20 units of used oil as a raw material. Assuming in scenario (1) that a re-refinery model processing 20 units of used oil produces 10 units of lubricating oil and 10 units of fuel products, then adequate units of crude oil would need to be processed in a fuel refinery model to produce 80 units of fuel products.
Then assuming in comparison scenario (2) that the 20 units of used oil can be used to produce 20 units of fuel products. Then adequate units of crude oil would need to be processed in a fuel/lubes refinery model to produce 10 units of lubricating oil, and 70 units of fuel products.
In each scenario, 20 units of used oil are involved in the production of 10 units of lubricating oil and 90 units of fuel products.

Other scenarios or sub-scenarios in the application of the model will vary like the methods of converting used oils into lubricating oil, e.g., rejuvenation or various types of re-refining; and the methods for producing fuel products from used oils, e.g., industrial fuel production with filtration along with, or followed by, chemical and heat processing.

The main environmental impacts addressed would include:

- air emissions (main pollutants as well as air toxics) – eco and human toxicity;
- releases to land - eco and human toxicity;

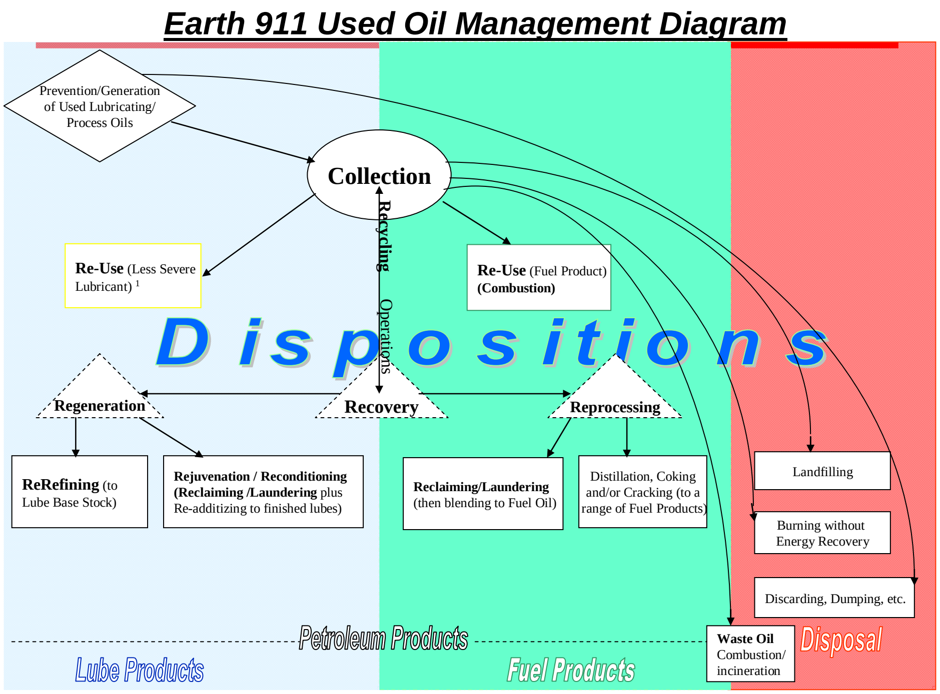
    - releases to water – eco and human toxicity;
    - global warming potential;
    - resource depletion.

Potential sources of data include:

- For production of base oil/lubricants derived from used oil:
    - Evergreen/Newalta/Mohawk process and Safety-Kleen;
    - NORA members;
    - GEIR/Viscolube.
- For production of fuel products derived from crude oil/natural gas:
    - member companies of the API.
- For production of fuel products derived from used oil from various processes:
    - member companies of NORA (processes such as filtration, dewatering, chemical and heat processing, DeMenno-Kerdoon process, Shurtleff process -Atlantic Industrial Services/Unitek Solvent Services);
    -
- For production of base oils/lubricants derived from crude oil:
    - member companies of the API
- For various fuel uses:
    - asphalt manufacture (Entropy study);
    - power plants (Florida Power and Light & Utility Solid Waste Activity Group);
    - cement production (Lafarge);
    - space heater fuel (Vermont Space Heater Study and/or more recent data, if available, from Clean Burn and EnergyLogic).
- For various lubricant uses:
    - member companies of the API.
- For generation rates for used lubricating oils:
    - API, NORA, governments.
- For collection rates for generated used oils:
    - API, NORA, governments, Bearing Point, Sofres, OECD, and other existing study data sources.
- For impact of leakage and inappropriate disposal of used lubricating oils:
    - Governments, NORA.

In addition data will be sought from the scientific literature and from applicable studies carried out elsewhere, for example in Europe.

Several diagrams follow which represent convenient references for points made in the text above.



ISO 14049, Figure 9: Illustration of the concept of balancing to equal products when comparing life cycles.

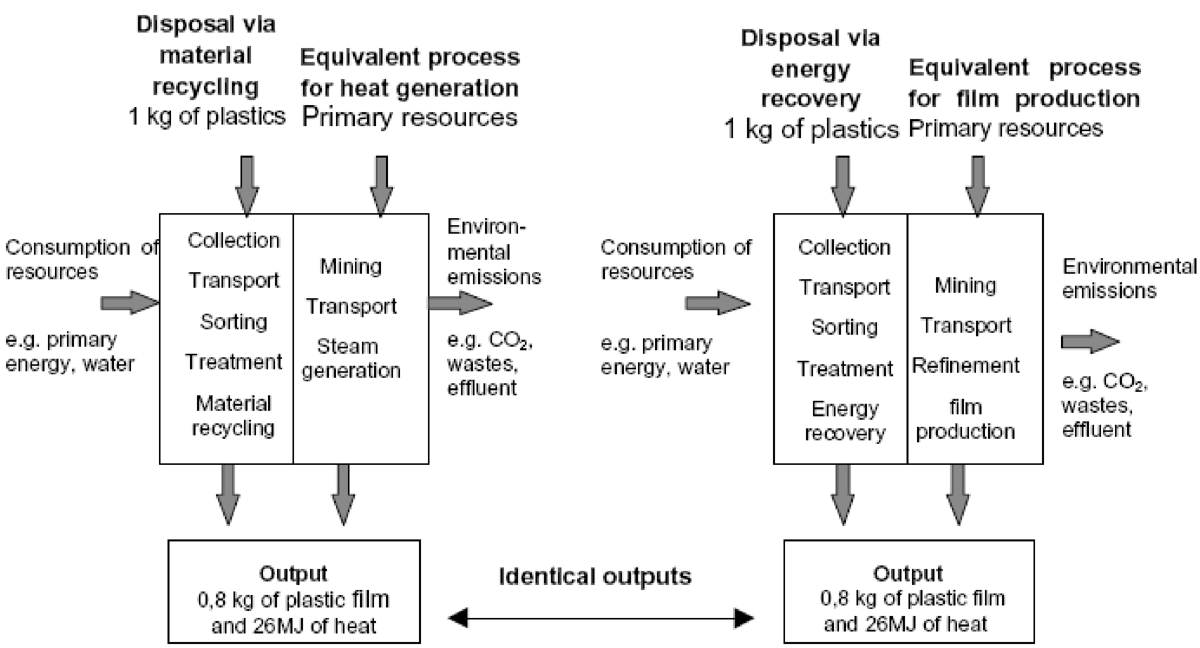
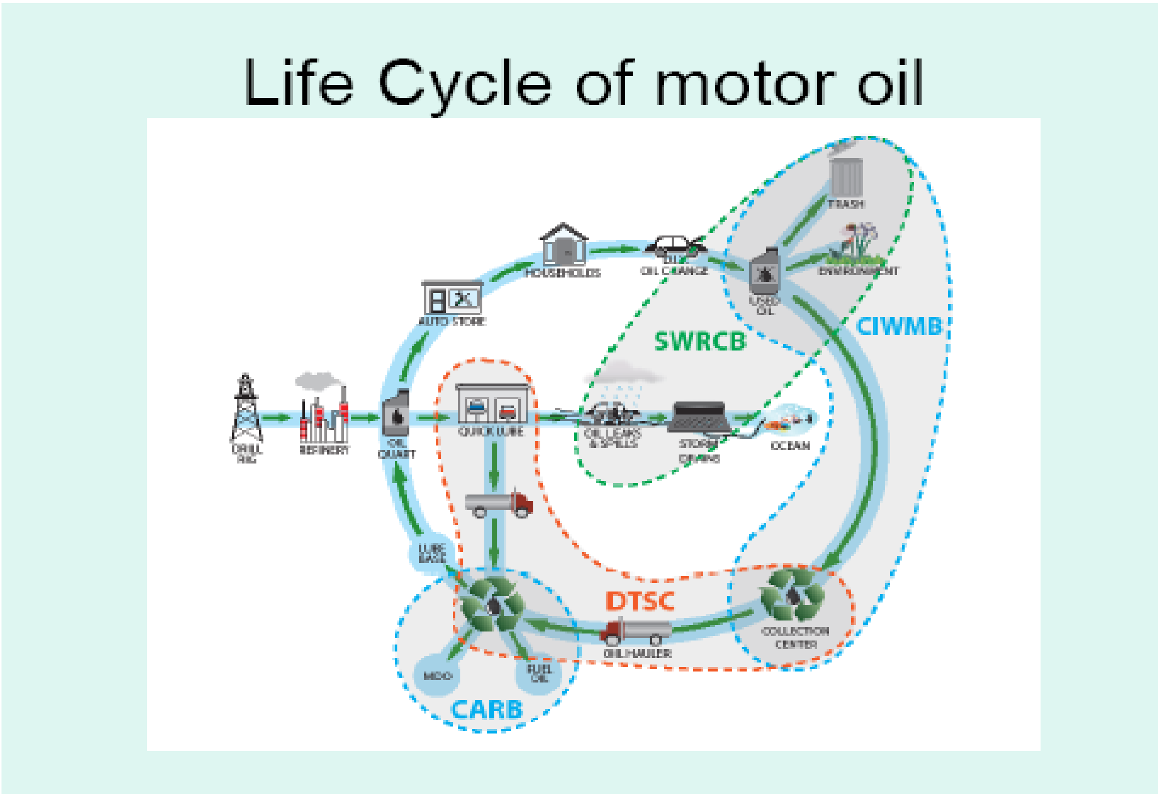


Figure 9 – Example of an expansion of the system boundaries

Life Cycle of Motor Oil (from Bob Boughton's May 28, 2008 symposium presentation) illustrating the areas of responsibility of regulatory agencies in California.



ISO 14040, Figure 2 – example of a product system for LCA. This diagram illustrates considerations that need to be made in establishing system boundaries within the system environment. Elementary flows into and out of the system boundary must be accounted for. Products that result from other systems need to be accounted for as do products from the system that pass to other systems.

EXAMPLES

Elementary flows entering the unit process:	crude oil from the ground and solar radiation.
Elementary flows leaving the unit process:	emissions to air, discharges to water or soil and radiation.
Intermediate product flows:	basic materials and subassemblies.
Product flows entering or leaving the system:	recycled materials and components for reuse.

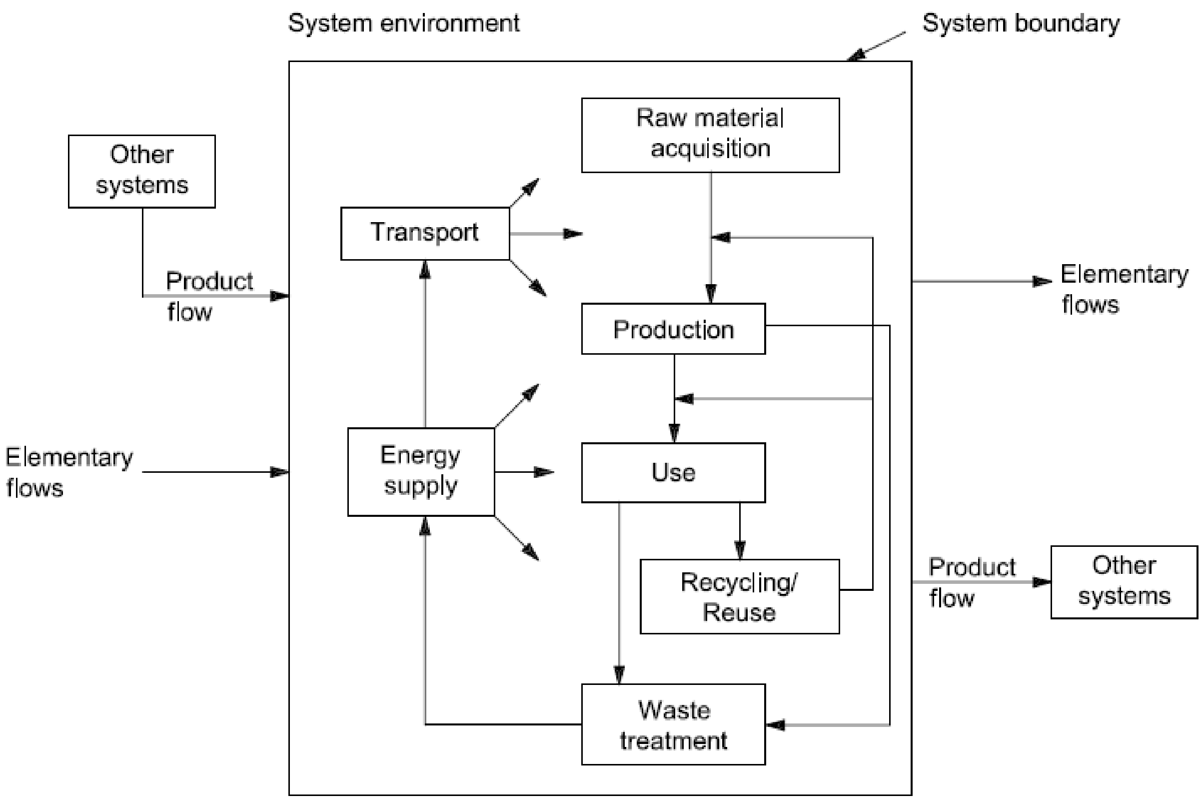


Figure 2 — Example of a product system for LCA