Influencing State Government Hazardous Waste Management Policy and Product Procurement Using LCA

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Background

- The mission of the California EPA is to restore, protect and enhance the environment, to ensure public health, environmental quality, and economic vitality. Underlying themes include considering sustainability and multimedia impacts in environmental decision making.
- Within California EPA, the Department of Toxic Substances Control oversees hazardous waste management. The Department's pollution prevention program is developing LCA as a tool for evaluating the impacts of alternative systems and measuring progress towards sustainability.
- This paper presents a synopsis of the preliminary results from a case study contained in a technical report under preparation.

Used oil management in California

- Over 80 million gallons of California generated used oil is processed in-state by permitted used oil recycling facilities each year.
- The volumes treated and products produced for the three primary management methods are shown below (millions of gallons per year):

Management method	Volume treated	Product distribution
Re-refined	11	8 to lube base stock 2 to asphalt tar
Processed to MDO	25	11 to marine diesel oil 14 to asphalt flux
Blended to fuel oil	44	45* to bunker fuel

*includes ~1 MG of light ends/gas-oil fraction from re-refining sent to fuel blending

Rationale for the study

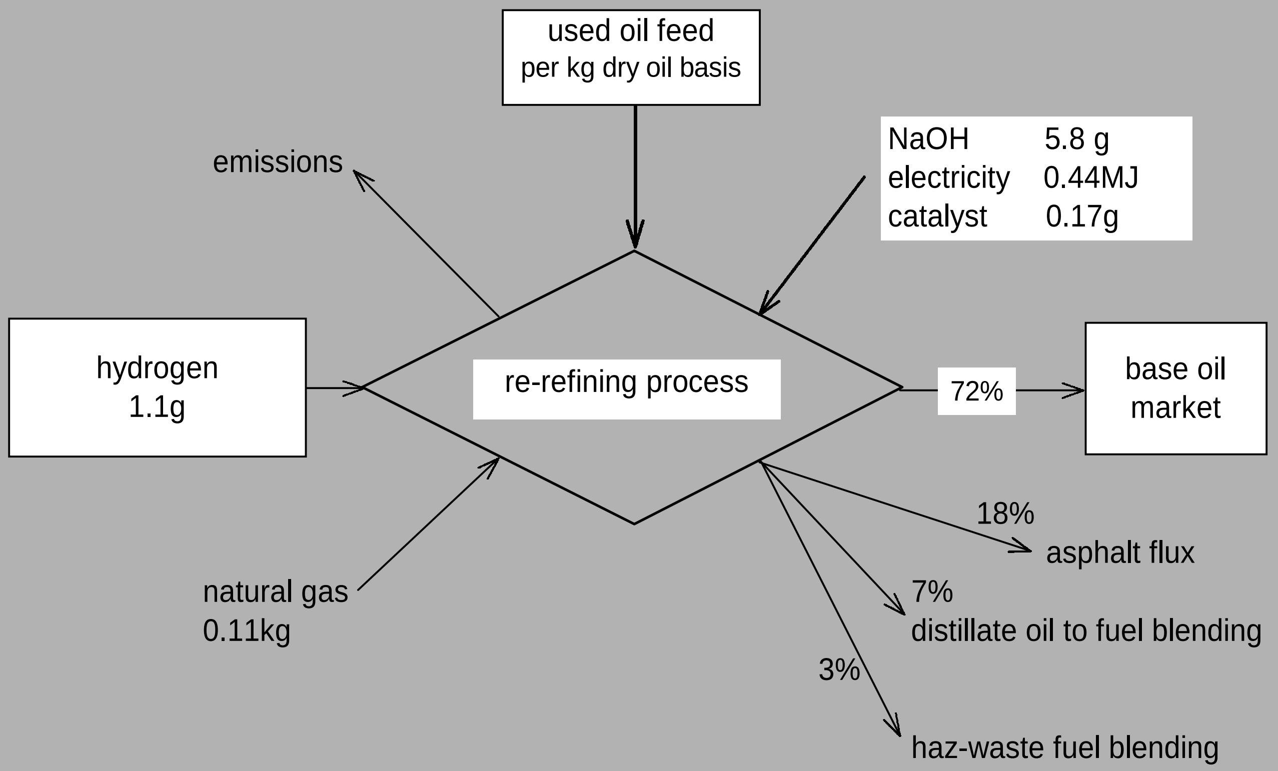
- Used oil was chosen as a case study because it is the largest hazardous waste stream in the state and the major management methods are substantially different.
- Untreated used oil fuel contains relatively high levels of heavy metals as well as phosphates and sulfur from additive chemicals. As a result, compared to virgin based heavy fuel oil, combustion of used oil fuels may impact human health and the environment.
- Comparing the overall impacts and benefits of used oil management options using LCA will provide a clearer picture of the human health and environmental trade-offs. Hazardous waste management policy and recycled content product procurement policy could benefit from quantification of impacts from used oil management.

Comparative simplified LCA- re-refining vs direct use as fuel

- Boundary of study
  - The manufacturing of motor oil, transportation, and the use of motor oil as well as collection of used oil phases were excluded. These were considered to be equivalent, regardless of the end of life scenario chosen.
  - The study was focused on the end-of-life phase to highlight two cases:
    - Re-refining with off-set credit for products from re-refining (data from Evergreen Oil re-refining facility in California)
    - Combustion of used oil as fuel with off-set credit for displacing crude oil derived heavy fuel oil consumed as fuel.
- GaBi 3 software was used to conduct a comparative LCA using the problem oriented approach (CML).

Process flowchart for re-refining

(kg of dry used oil basis)



Modeling, data sources and assumptions

- Re-refining process information was gathered from facility data (Evergreen Oil) and reports to Government agencies.
- Used oil characteristics were gathered from certified laboratory data from California used oil management facilities and Department files (representing bulk oil characteristics).
- Laboratory data (Department lab) supports the contention that heavy metal contaminants are not leachable from asphalt tar or asphalt flux matrix. Hence, there are no impacts from the use of the asphalt products.
- Most used oil fuel is combusted outside of the US in systems with limited emission control. It was assumed that no emission controls are in place for used oil fuel combustion (worse case scenario for comparison of the methods, evaluated by sensitivity analyses).
- GaBi 3 data sets were used for every process except for the combustion used oil as fuel output data for heavy metals, chloride and sulfur emissions to air and phosphate emissions to water.

Used oil and #4 fuel oil contaminant concentration data (ppm)

	California used oil fuel		#4 fuel oil
Element	Average(n=10)	Range	
Barium	18	12-26	<1
Lead	33	18-38	<10
Cadmium	1	<1-2	<0.25
Chromium	1.4	<1-2	<2
Copper	40	28-64	na
Nickel	1	<1-1.7	8.3
Zinc	822	600-877	9
Chlorides (total)	100	---	<200
Phosphorus (total)	790	690-840	na
Sulfur (total)	3200	2930-3375	1860
ash	0.5 wt %	0.32-0.87 wt %	0.56 wt %

Life-Cycle Inventory

- Net emissions benefits for many elements and compounds (negative emissions) result from the recovery of useful products or energy resources for each case. Also, most parameters are equivalent between the cases.
- For the used oil as fuel case, heavy metal emissions to air are several orders of magnitude higher than virgin fuel combustion. Zinc, lead, chromium and cadmium constitute the majority of the difference.

Characterization

- Benefits (negative impacts) result for every environmental impact category in the re-refining case due to the product recovery off-sets exceeding the impacts from the re-refining process.
- Both impacts and benefits result from the used oil fuel case. Benefits are gained in some categories due to the energy recovery off-set exceeding the impacts from used oil combustion.
- Between the two cases, comparable benefits result for several categories and several categories are relatively small and can be ignored.
- Overall, the potential impacts on terrestrial ecotoxicity and human toxicity for the used oil as fuel case dominate the comparison.

Characterization of impacts and benefits

(per 1000 kg used oil basis)

Environmental impact category	Used oil as Fuel case: impacts	Used oil as Fuel case: benefits	Re-refining case: benefits
Terrestrial ecotoxicity potential [kg DCB-Equiv.]	680000		1300
Human toxicity potential [kg DCB-Equiv.]	2700		14
Eutrification potential [kg Phosphate-Equiv.]	1.6		0.16
Aquatic ecotoxicity potential [kg DCB-Equiv.]	0.75		0.52
Winter Smog [kg SO2-Equiv]	0.65		0.97
Heavy metals [kg Pb-Equiv.]	0.088		0.00058
Ozone depletion potential [kg R11-Equiv.]		0.00085	0.001
Carcinogenic substances (EI 95) [kg PAH-Equiv.]		0.0066	0.000067
Acidification potential [kg SO2-Equiv]		0.21	1.5
Photochemical oxidant potential [kg Ethene-Equiv.]		2.7	3.0
Ionizing radiation El 95 AF [Bq I129-Equiv.]		58	16
Global warming potential (100 yr) [kg CO2-Equiv.]		260	290

Consideration of boundary conditions

- Re-refining facility operation will lead to local and regional impacts such as aquatic ecotoxicity, acidification and human toxicity. However, the regional impacts are offset by the assumption of reduced local crude oil refining capacity (off-set benefits). The local impacts are relatively small, constituting small fractions of the off-set benefits for each characteristic. A doubling or even tripling of local sensitivity to the impacts from re-refining would not alter the findings of the study.
- Very little used oil fuel is consumed in California. Strict air emission requirements has lead to the use of high quality low polluting fuels such as natural gas. Also, the high ash content of used oil fuel reduces the value of the material as a fuel in most boiler applications.
- Over 40 million gallons of untreated used oil is consumed as fuel outside of California following blending with virgin stock and residual fuels (Mexico and Far East). As a result, the local and regional impacts are much more geographically distributed compared to the re-refining case.

Sensitivity considerations

- The difference between the cases is dominated by heavy metal air emissions. Lead and chromium contribute 99% of the human toxicity potential and zinc and cadmium contribute 99% of the terrestrial ecotoxicity potential to the used oil as fuel case.
- The results are not sensitive to other variables such as re-refining process yields or concentration of other constituents in used oil.
- The assumption of no emission controls for the used oil as fuel case is conservative, however, sensitivity analyses show that emissions control would need to be over 90% effective for heavy metals reduction before the fuel case becomes comparable to that of re-refining. Most end uses of used oil derived fuels have emission controls below this level.
- The result for the human toxicity impact is overstated. A majority of used oils are blended with virgin stock and placed on the world fuel market. While the heavy metal concentrations of the final blended fuel may be very low, the net mass of heavy metals emitted over time will be the same. However, the actual exposure of humans may be under a threshold concentration for impact.

Conclusions

- Over 120 tons of heavy metal air emissions may result from combustion of California generated used oil as fuel each year. Alternatively, the current volumes treated by re-refining and processing to MDO methods result in a reduction of about 120 tons of heavy metal emissions. (Treatment of used oil by distillation to produce Marine Diesel Oil fuel mitigates heavy metal emissions problem and presents net benefits equivalent to the re-refining case.)
- The majority of potential impacts from used oil combustion are outside of California's borders. Technically the boundaries of the cases studied are dis-congruent geographically, but the results are still interesting from a holistic perspective.
- California's global environmental footprint can be reduced by changing used oil management policy and by supporting markets for products derived from used oil treatment. These LCA results can be used to influence both procurement policy and hazardous waste management policy.

Influencing government and business procurement (market incentive approach)

- These results are being shared with major state procurement agencies and procurement policy developers. A statewide recycled content procurement requirement is likely if performance and cost are equal.
- These results help to qualify the benefits of re-refined oil products where only equal cost and performance were considered before. Two applications for this additional information include:
  - A sister agency (California Integrated Waste Management Board) is implementing recycled content purchasing requirements for local and state government agencies.
  - The Department and USEPA provide recycled content product information in pollution prevention program outreach to business.
- A large market for asphalt flux is currently unavailable in-state. Increased asphalt flux markets will support the greater distillation of used oil into MDO. Support for the development of performance based standards for asphalt concrete within California is needed.
- Subsidized loans for treatment facilities to construct, upgrade or add capacity could be made available. Options are being explored.

Influencing state hazardous waste management policy (regulatory approach)

- The LCA results are being shared with hazardous waste management policy makers at the Department. The question is, will the LCA results be motivational considering that the life-cycle impacts from used oil fuel combustion are primarily out-of-state and the life-cycle impacts from additional used oil treatment facility capacity are in-state?
- Some options for action include:
  - Can/should there be different permit and operating standards for re-refining or distillation (MDO) facilities compared to fuel blending?
  - Can/should the heavy metal concentration limits be lowered for used oil marketed as fuel?
  - Can/should a universal waste rule strategy be applied to provide market incentive for used oil treatment?

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