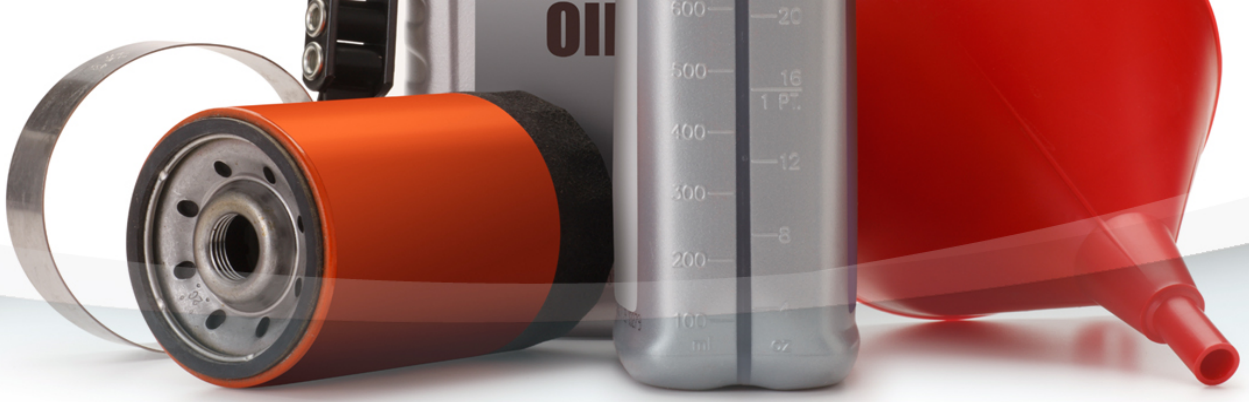
Used Oil LCA

CalRecycle

10/29/2013



Background

SB 546 – 2009

- Many changes, LCA one small part
- $0.02 per gallon fee
- Somewhat vague requirement
- Include broad stakeholder participation

Initial Stages

- Fall 2010

Report to Legislature due Jan 1, 2014

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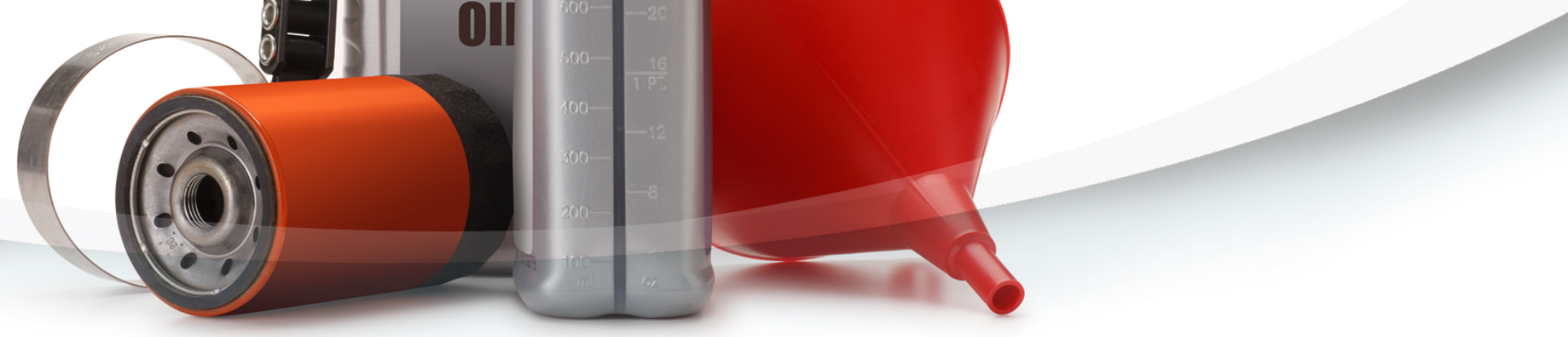

What is an LCA

A compilation and evaluation of the inputs, outputs and the potential impacts of a product system throughout its life cycle.

ISO 14040, 14044, 14049

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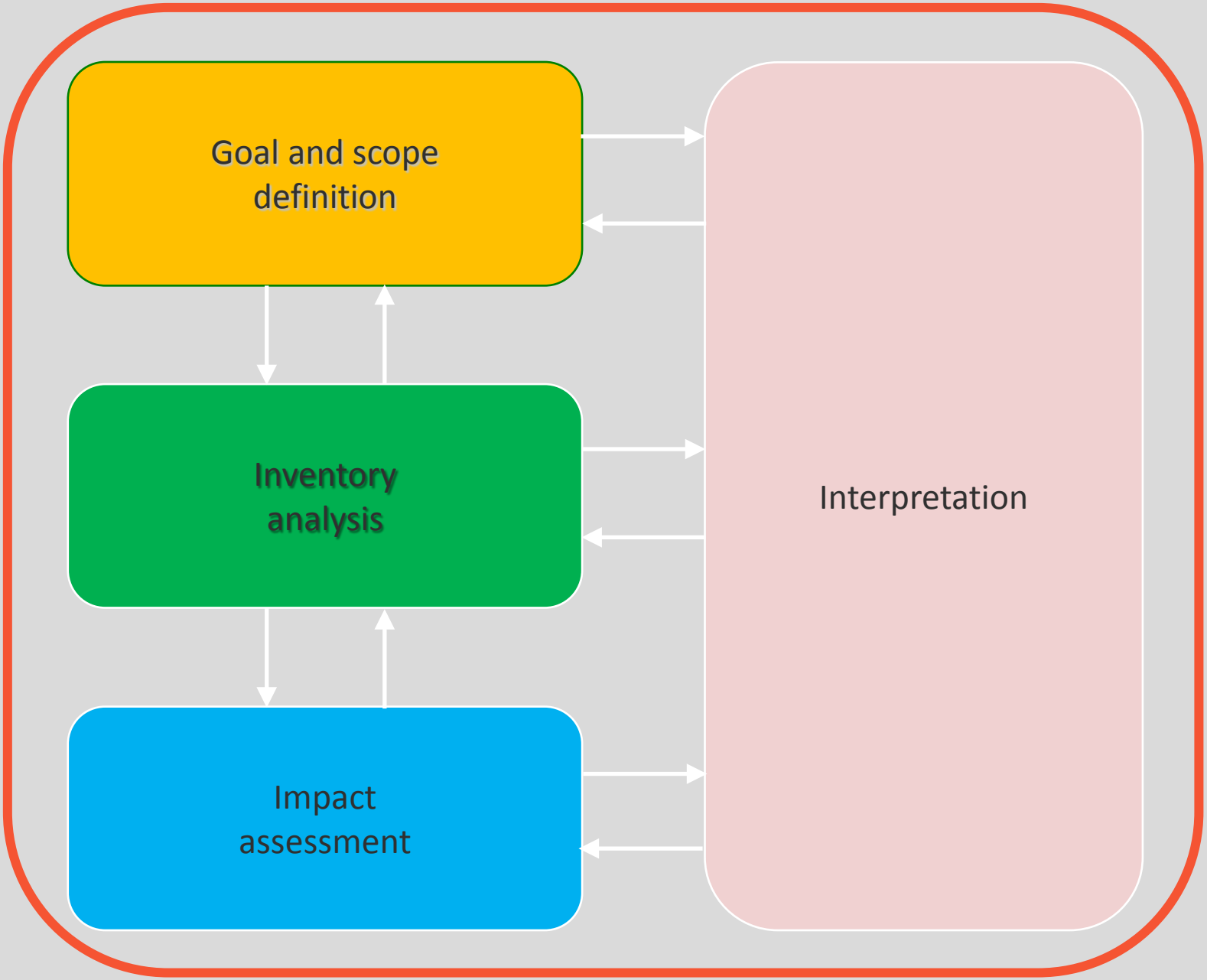
Goal and scope definition
Inventory analysis
Impact assessment
Interpretation

Used Oil LCA Details

- Functional Unit
  - All used oil generated or managed in CA
- Scope
  - When oil becomes used
  - 2010=base year
  - 20-year time horizon
- Boundaries
  - Emissions followed regardless of source location

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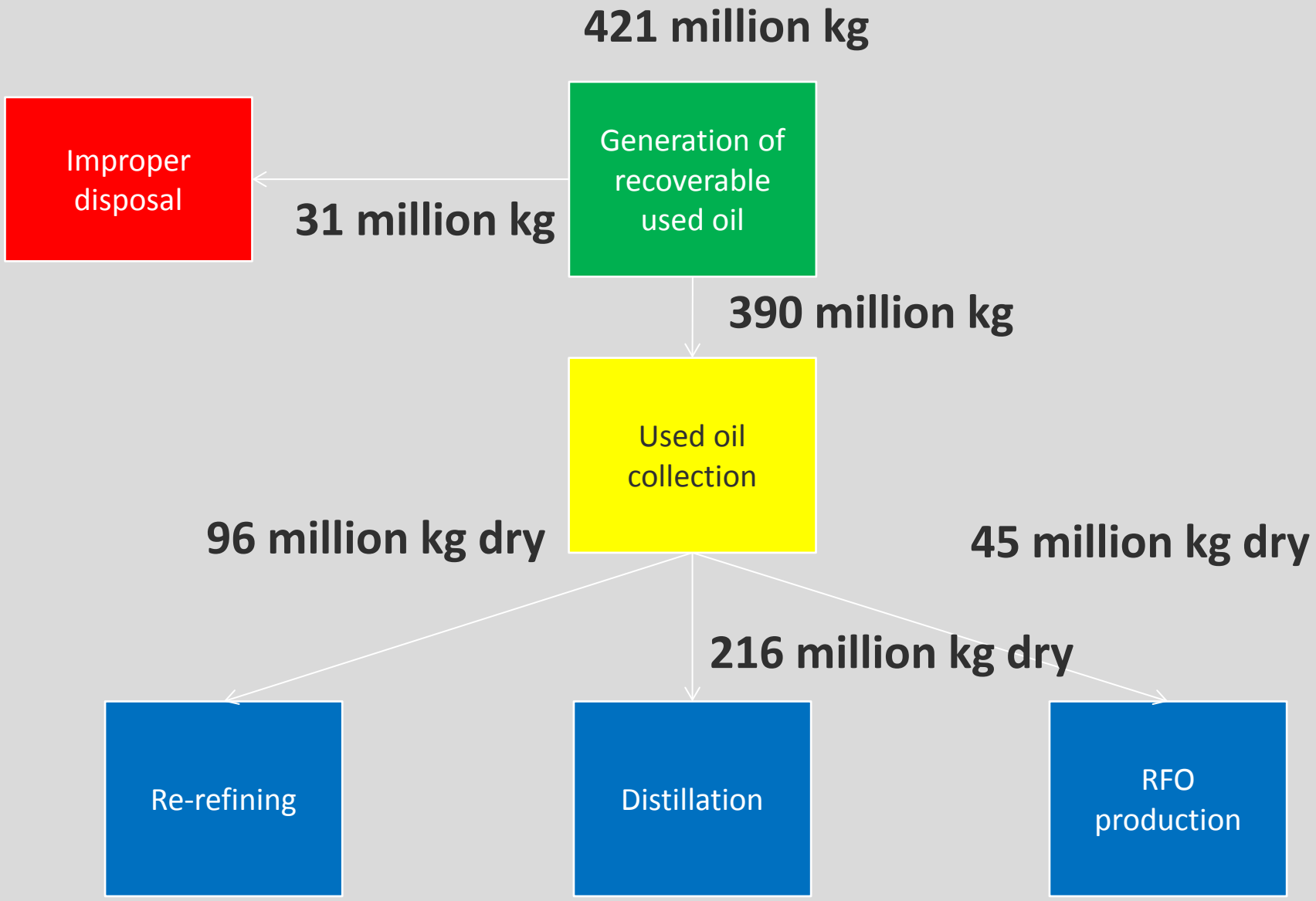
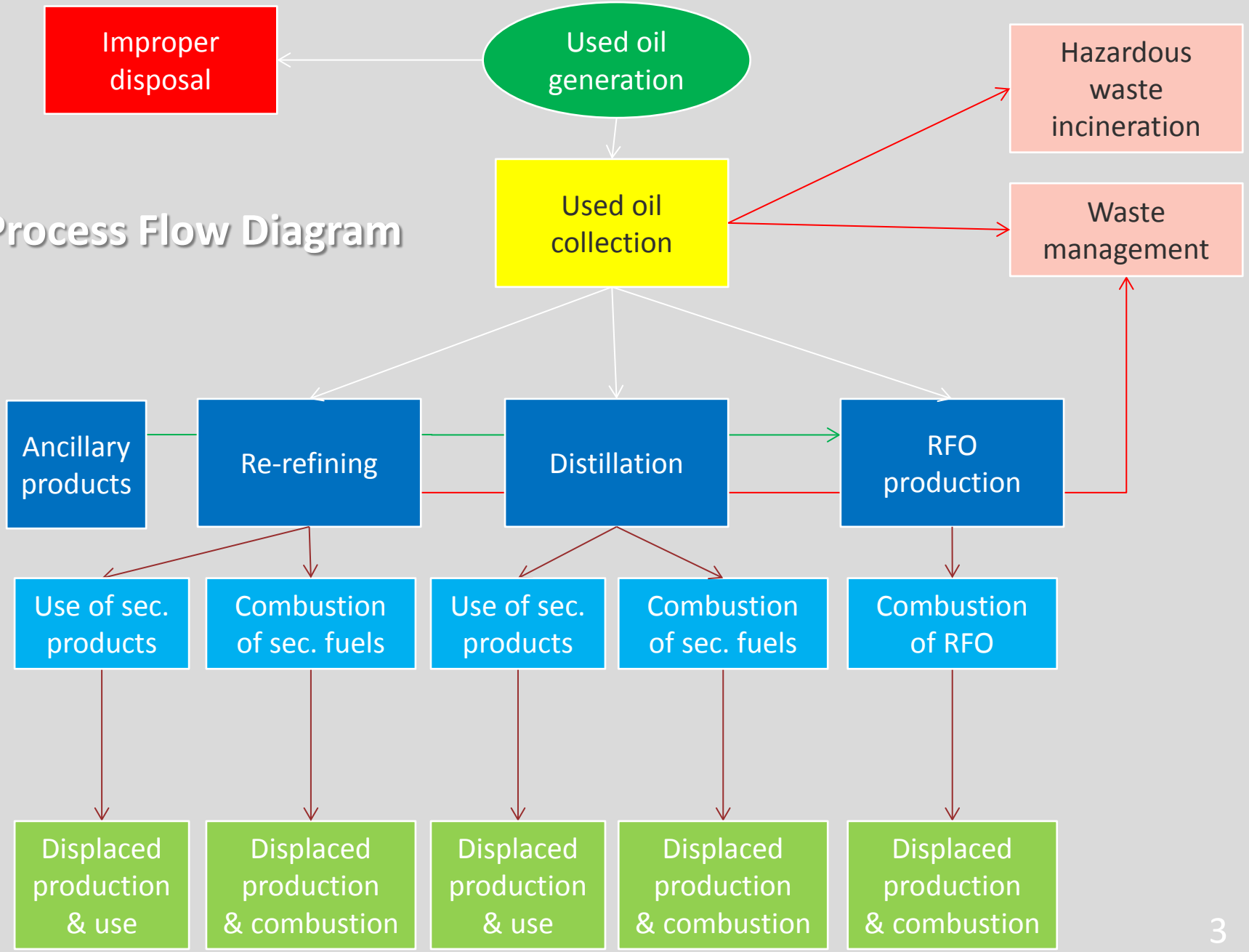
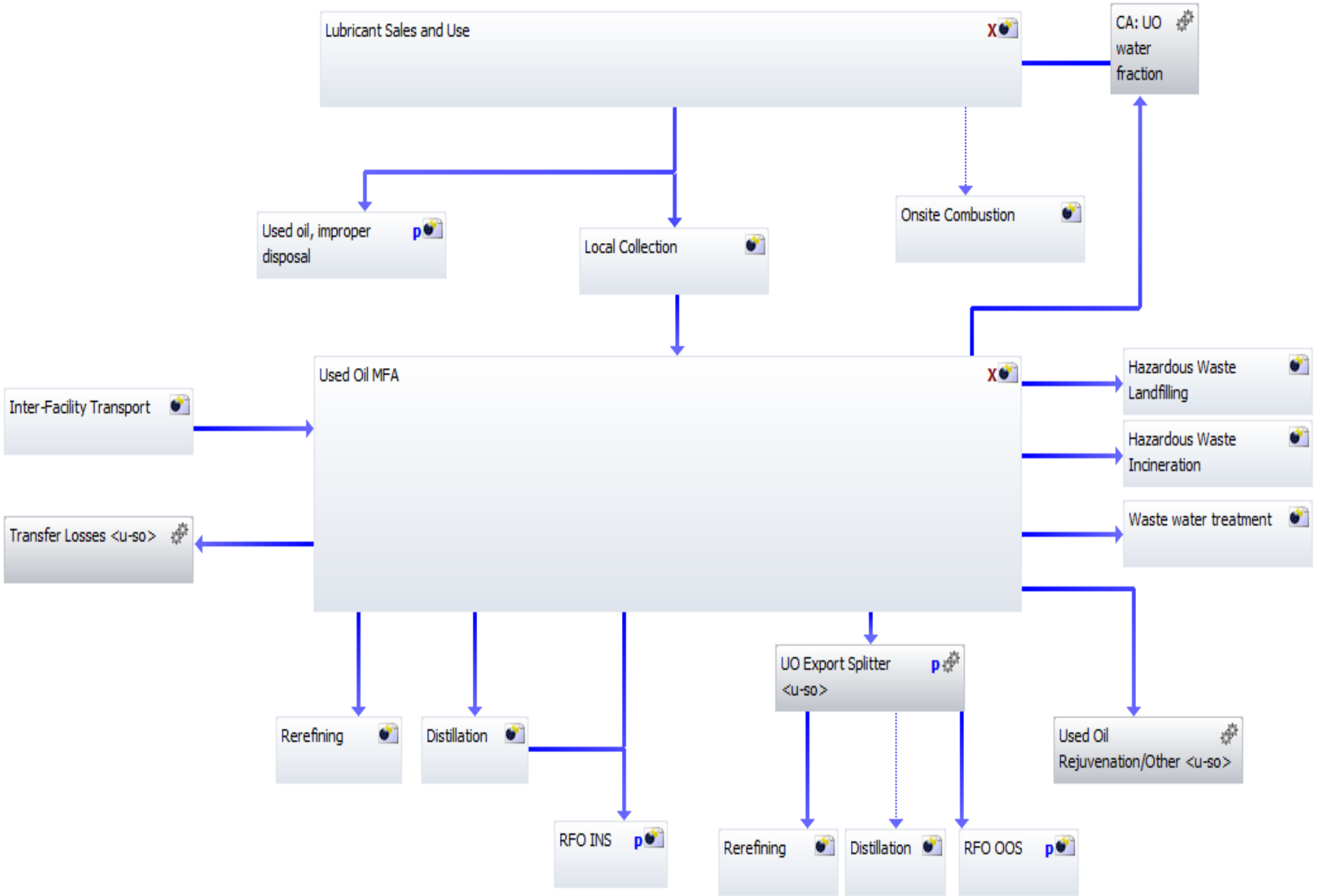
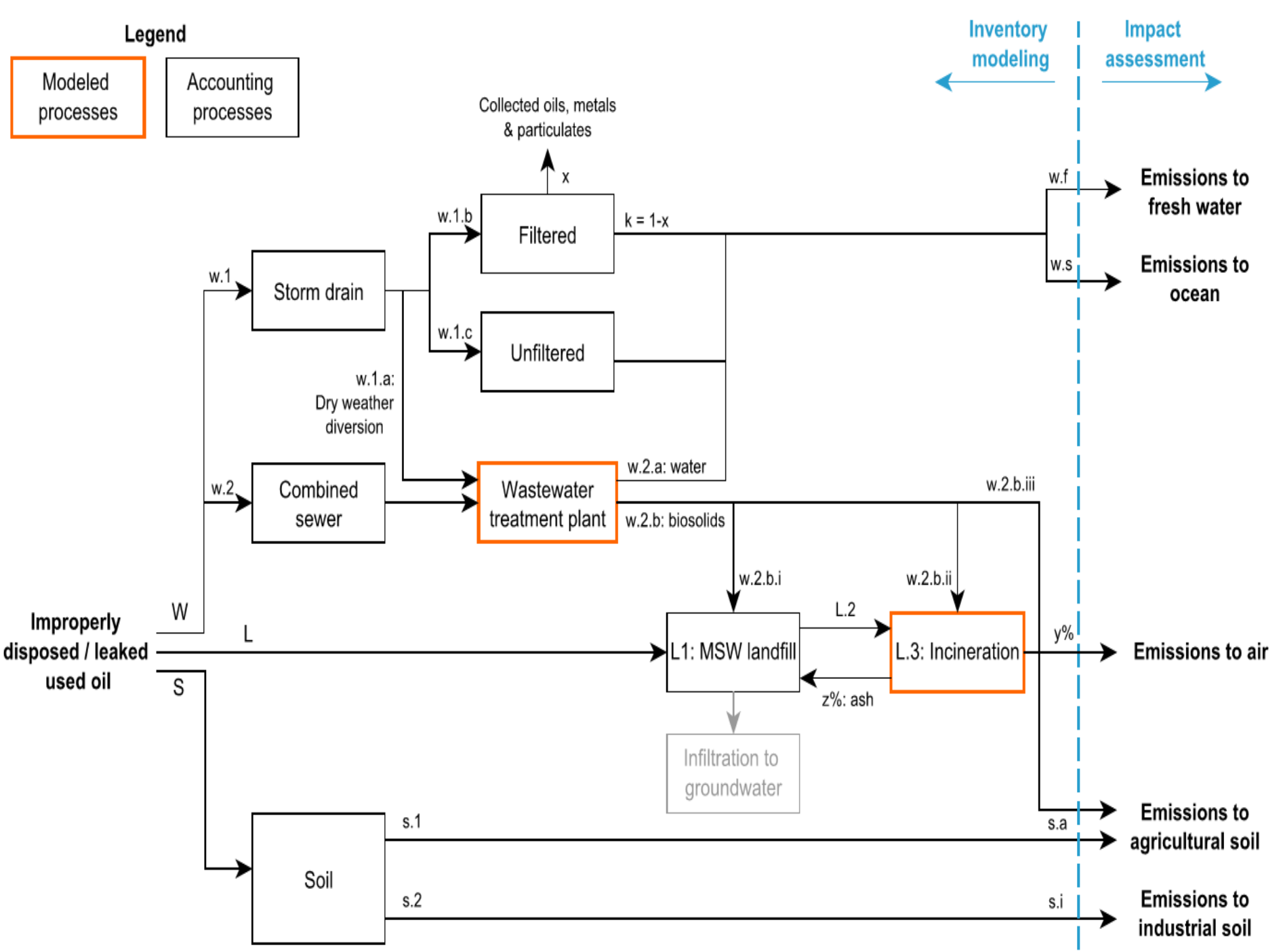

421 million kg
Improper disposal
31 million kg
Generation of recoverable used oil
390 million kg
Used oil collection
96 million kg dry
45 million kg dry
216 million kg dry
Re-refining
Distillation
RFO production

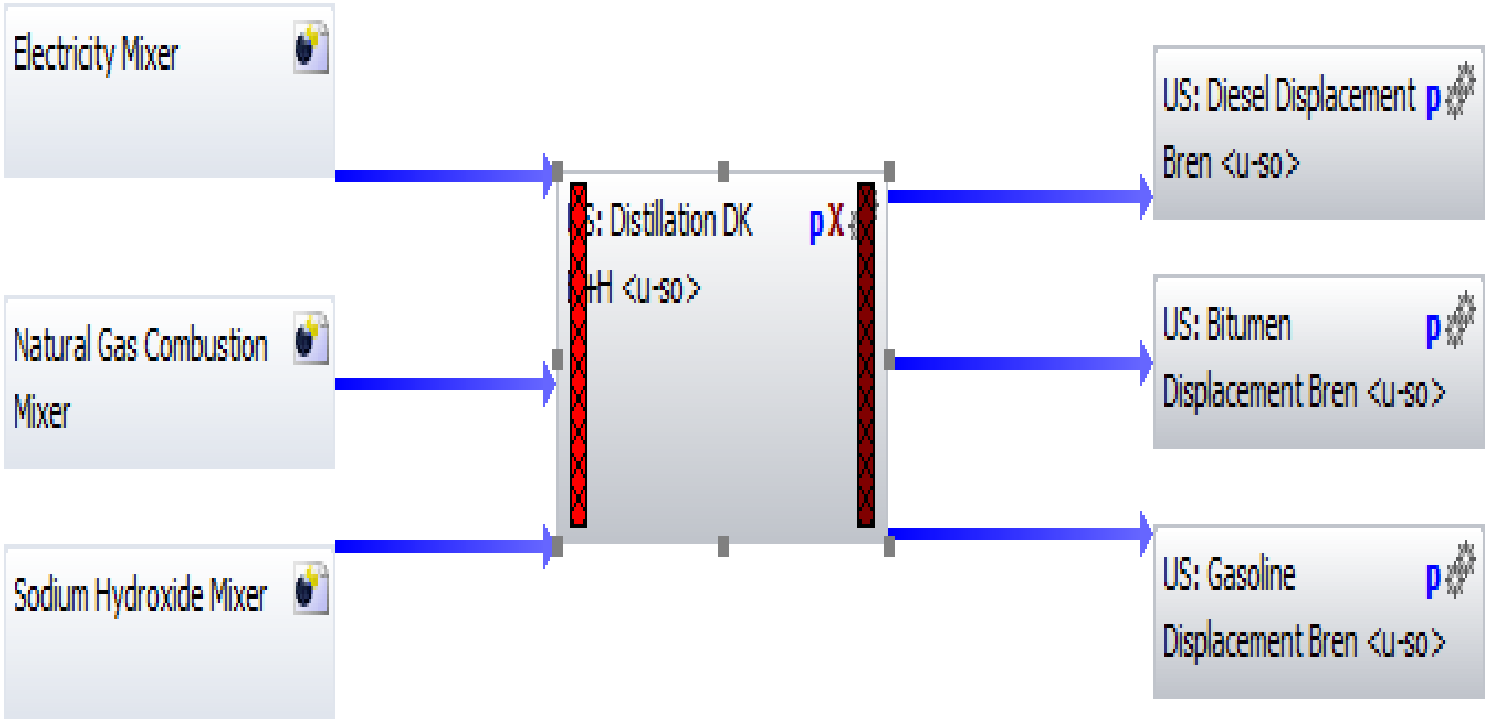
Process Flow Diagram



e names of the basic processes are shown.




Legend
Modeled processes
Accounting processes
Inventory modeling
Impact assessment
Collected oils, metals & particulates
x
w.1.b
Filtered
k = 1-x
w.f
Emissions to fresh water
w.s
Emissions to ocean
w.1
Storm drain
w.1.c
Unfiltered
w.1.a: Dry weather diversion
w.2
Combined sewer
Wastewater treatment plant
w.2.a: water
w.2.b: biosolids
w.2.b.iii
w.2.b.i
w.2.b.ii
Improperly disposed / leaked used oil
W
L
S
L1: MSW landfill
L.2
L.3: Incineration
y%
Emissions to air
z%: ash
Infiltration to groundwater
s.a
Emissions to agricultural soil
s.1
Soil
s.2
s.i
Emissions to industrial soil


Electricity Mixer
Natural Gas Combustion Mixer
Sodium Hydroxide Mixer
S: Distillation DK
H <u-so>
US: Diesel Displacement Bren <u-so>
US: Bitumen Displacement Bren <u-so>
US: Gasoline Displacement Bren <u-so>

Scaling factor: 1 Fixed

Free parameters

Fixed parameters

Inputs

Alias	Flow	Quantity	Amount	Unit	Tra
	Energy, kinetic (in wind), conve	Energy (n	0.000113	MJ	
	Energy, potential (in hydropow	Energy (n	0.00291	MJ	
	Energy, solar, converted [Rene	Energy (n	3.2E-006	MJ	
	Feldspar (aluminium silicates) [	Mass	2.01E-012	kg	
	Fluorine [Non renewable eleme	Mass	2.79E-008	kg	
	Fluorspar (calcium fluoride; fluo	Mass	5.77E-007	kg	
	Gallium [Non renewable elemen	Mass	5.86E-015	kg	
	Gold [Non renewable elements]	Mass	1.78E-012	kg	
	Granite [Non renewable resour	Mass	1.06E-014	kg	
	Gypsum (natural gypsum) [Non	Mass	1.41E-009	kg	
	Hard coal ecoinvent [Hard coal	Mass	0.00155	kg	
	Indium [Non renewable elemen	Mass	1.86E-012	kg	
	Iodine [Non renewable element	Mass	2.09E-012	kg	
	Iron [Non renewable elements]	Mass	0.000178	kg	
	Kaolinite (24% in ore as mined)	Mass	1.99E-008	kg	
	Kieserite (25% in ore as mined)	Mass	6.94E-011	kg	
	Lead [Non renewable elements	Mass	1.26E-007	kg	
	Lignite ecoinvent [Lignite (reso	Mass	0.000225	kg	
	Limestone (calcium carbonate)	Mass	0.000123	kg	
	Lithium [Non renewable elemen	Mass	1.72E-014	kg	
	Magnesit (Magnesium carbonat	Mass	2.51E-006	kg	
	Magnesium [Non renewable ele	Mass	1.41E-011	kg	
	Manganese [Non renewable ele	Mass	1.01E-007	kg	
	Metamorphic stone, containing	Mass	1.24E-009	kg	
	Molybdenum [Non renewable el	Mass	3.49E-008	kg	
	Natural Aggregate [Non renew	Mass	0.0012	kg	
	Natural gas ecoinvent [Natural	Standard \	0.0308	Nm3	
	Nickel [Non renewable element	Mass	2.42E-006	kg	
	Occupation, arable, non-irrigat	Areatime	7.98E-008	m2*yr	
	Occupation, construction site [	Areatime	3.43E-006	m2*yr	
	Occupation, dump site [Hemero	Areatime	1.74E-005	m2*yr	
	Occupation, dump site, bentho	Areatime	7.58E-006	m2*yr	
	Occupation, forest, intensive [	Areatime	3.85E-007	m2*yr	
	Occupation, forest, intensive, r	Areatime	6.1E-005	m2*yr	
	Occupation, forest, intensive, s	Areatime	2.44E-007	m2*yr	
	Occupation, industrial area [He	Areatime	1.07E-005	m2*yr	
	Occupation, industrial area, bei	Areatime	7.42E-008	m2*yr	
	Occupation, industrial area, bui	Areatime	8.86E-007	m2*yr	

Show all flows

Outputs

Alias	Flow	Quantity	Amount	Unit	Tra
	Aniline [Hydrocarbons to fresh	Mass	1.69E-014	kg	
	Aniline [Group NMVOC to air]	Mass	7.03E-015	kg	
	Anthranilic acid [Group NMVOC	Mass	1.83E-017	kg	
	Antimony [Heavy metals to agr	Mass	4.17E-016	kg	
	Antimony [Heavy metals to air]	Mass	8.58E-011	kg	
	Antimony [ecoinvent long-term	Mass	2.44E-009	kg	
	Antimony [Heavy metals to fres	Mass	3.98E-010	kg	
	Antimony (Sb122) [Radioactive	Activity	6.32E-009	Bq	
	Antimony (Sb124) [Radioactive	Activity	1.93E-006	Bq	
	Antimony (Sb124) [Radioactive	Activity	1.57E-011	Bq	
	Antimony (Sb125) [Radioactive	Activity	1.64E-010	Bq	
	Antimony (Sb125) [Radioactive	Activity	1.89E-006	Bq	
	Argon (Ar41) [Radioactive emis	Activity	0.000826	Bq	
	Aromatic hydrocarbons (unspe	Mass	5.07E-009	kg	
	Aromatic hydrocarbons (unspe	Mass	8.67E-009	kg	
	Arsenic (+V) [Heavy metals to i	Mass	5.82E-011	kg	
	Arsenic (+V) [Heavy metals to a	Mass	9.28E-010	kg	
	Arsenic (+V) [Heavy metals to s	Mass	1.17E-010	kg	
	Arsenic (+V) [Heavy metals to t	Mass	1.6E-008	kg	
	Arsenic (+V) [Heavy metals to a	Mass	5.45E-013	kg	
	Atrazine [Pesticides to agricultu	Mass	1.89E-016	kg	
	Barium [Inorganic emissions to a	Mass	1.27E-013	kg	
	Barium [Inorganic emissions to t	Mass	2.3E-007	kg	
	Barium [Inorganic emissions to s	Mass	3.15E-009	kg	
	Barium [Inorganic emissions to i	Mass	7.28E-008	kg	
	Barium [Inorganic emissions to a	Mass	2.19E-010	kg	
	Barium [ecoinvent long-term to	Mass	7.24E-008	kg	
	Barium (Ba140) [Radioactive en	Activity	1.06E-008	Bq	
	Barium (Ba140) [Radioactive en	Activity	2.77E-008	Bq	
	Barytes [Inorganic emissions to	Mass	4.72E-006	kg	
	Benomyl [Pesticides to agricultu	Mass	2.03E-014	kg	
	Bentazone [Pesticides to agricu	Mass	1.04E-013	kg	
	Benzal chloride [Halogenated o	Mass	5.49E-016	kg	
	Benzaldehyde [Group NMVOC t	Mass	1.51E-013	kg	
	Benzene [Group NMVOC to air]	Mass	4.24E-007	kg	
	Benzene [Hydrocarbons to sea	Mass	3.86E-010	kg	
	Benzene [Hydrocarbons to fres	Mass	2.6E-009	kg	
	Benzo{a}pyrene [Group PAH to	Mass	2.45E-011	kg	

LCA | LCC | LCWE

Inputs/Outputs

☑ Just elementary flows ☐ Separate IO tables

	Overview_AVH	Distillation	Distillation	Hazardous Wa	Hazardous Wa	Inter-Facility T	Local Collectio	Lubricant Sale	Onsite Combu	Rerefining	Rerefining	RFO INS	RFO OOS	Used Oil MFA	Used oil, impro	Waste water t	CA:
Flows	-1.03E011	-6.48E010		3.41E007	8.51E006	6.86E008	1.2E008			-2.29E010	-6.2E009	-6.45E009	-4.08E009		8.58E008	5.29E007	
Resources	-4.95E010	-3.15E010		2.36E007	6.25E006	3.31E008	5.78E007			-1.08E010	-2.93E009	-3.1E009	-1.96E009		3.95E008	2.68E007	
Emissions to air	-5.52E009	-4.96E009		1.74E006	3.56E005	9.2E007	1.61E007			-4.33E008	-1.17E008	-9.93E007	-6.28E007		4.66E007	-9.25E004	
ecoinvent long-term to air																	
Heavy metals to air	1.42E003	-154		6.51	4.02	2.92	0.511			-113	-30.7	1.04E003	655		10.4	0.00383	
Inorganic emissions to air	-5.29E009	-4.82E009		1.74E006	3.52E005	9.1E007	1.59E007			-3.78E008	-1.02E008	-8.59E007	-5.42E007		3.67E007	-4.43E004	
Organic emissions to air (group VOC)	-2.26E005	-1.18E006		1.08E003	1.48E003	1.91E004	3.34E003			-4.15E005	-1.12E005	-1.77E005	-1.12E005		1.75E006	491	
Other emissions to air	-2.22E008	-1.39E008				1.06E006	1.85E005			-5.52E007	-1.49E007	-1.36E007	-8.58E006		8.06E006	-4.87E004	
Particles to air	4.4E005	-1.41E004		466	2.15E003	2.73E003	452			-2.08E004	-5.63E003	2.87E005	1.81E005		6.11E003	-7.3	
Radioactive emissions to air	0.686	0.331		0.0336	0.00918	3.23E-007	5.64E-008			0.245	0.0662	-4.21E-006	-2.66E-006		0.0011	7.64E-008	
Emissions to fresh water	-4.75E010	-2.82E010		8.7E006	1.9E006	2.62E008	4.58E007			-1.16E010	-3.14E009	-3.24E009	-2.04E009		4.16E008	2.62E007	
Emissions to sea water	-2.23E008	-1.34E008		2.46E003	371	1.53E006	2.68E005			-4.87E007	-1.32E007	-1.74E007	-1.1E007		1.76E005	-1.38E003	
Emissions to agricultural soil	7.12E005	3.42E003		426	58.9	-2.3	-0.402			2.83E003	767	-4.78	-3.02		7.04E005	0.00113	
Emissions to industrial soil	6.44E004	1.48E003		107	36	9.39	1.64			895	242	-40.9	-25.8		6.17E004	0.216	

How is this LCA different from Others

- Functional Unit
- Scope
- Stakeholder Involvement
- Economic integration
- ~$3 million

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Contractors/pieces

13 Contracts

Meeting facilitation

LCA

LCA review

Economic analysis

Data Providers

Primary Data

Economic Analysis

- Direct Impacts/”microeconomic” model
- Cost Benefit
- External Monetization
- Regional Impacts/”macroeconomic” model

Stakeholders

Re-refiners

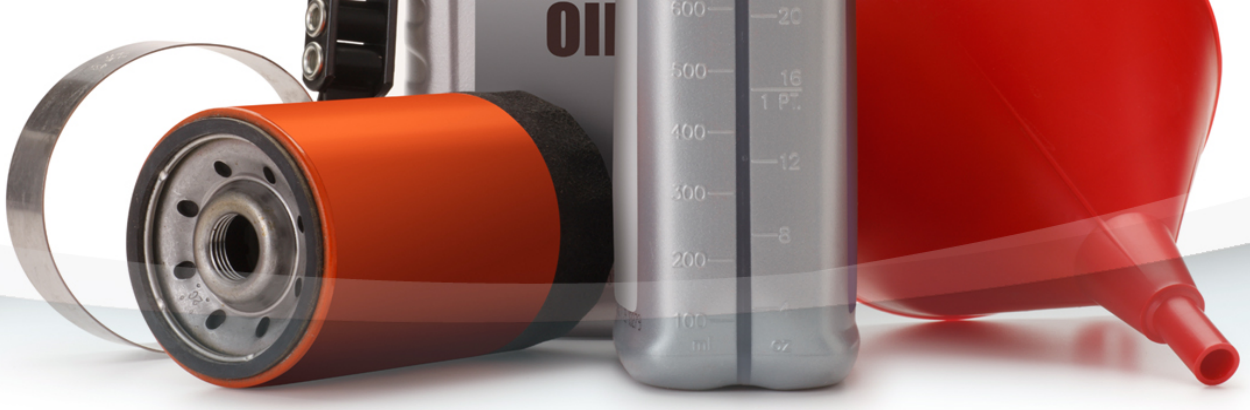
Used oil distiller

Virgin Petroleum Industry

Haulers

NORA

CAW



Completed Reports

- To be published shortly:
  - Environmental LCA
  - Direct Impacts Model
  - Cost-Benefits Model
  - Peer Review

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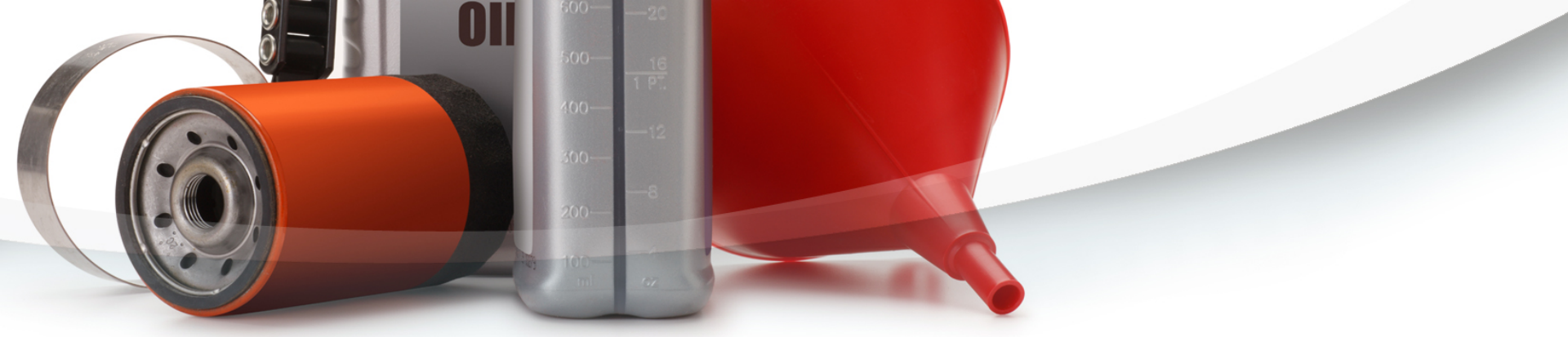

General Overall Findings

- Updated collection rates – higher than previously thought
- Lubricating oil demand tending slowly downward
- Uncollected Oil is poorly-accounted for

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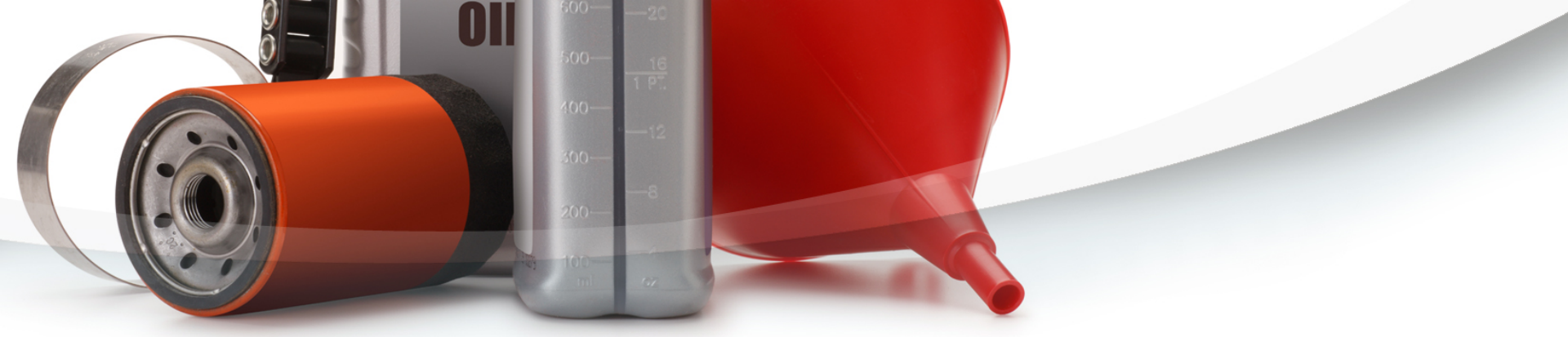

LCA Baseline

2010-2030

- Major Environmental impacts driven by three elementary flows
  - Zinc: Ecotoxicity and human health, non-cancer
    - USEtox characterization model
  - Phosphorus: Eutrophication
    - Oil composition and emission/retention assumptions
  - Non-methane VOC: Human health, cancer
    - Little data available

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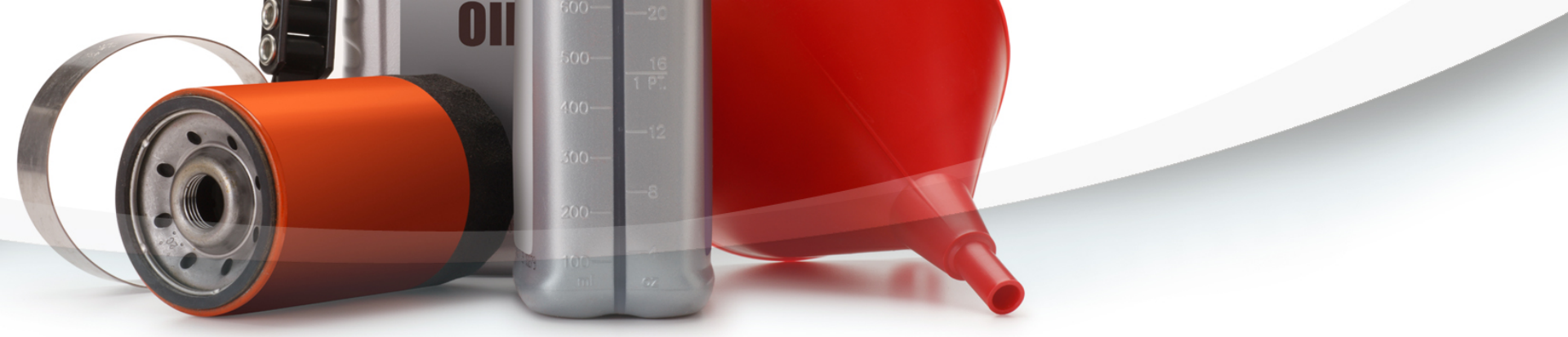

LCA "Extreme" Scenarios

- No single "best" disposition route for used oil
  - RFO may be slightly less desirable than other options
- Improper management is always worse.
  - Dumping has large ecotoxicity impacts
  - Combustion with no controls has large GHG, Smog, and particulate matter impacts.

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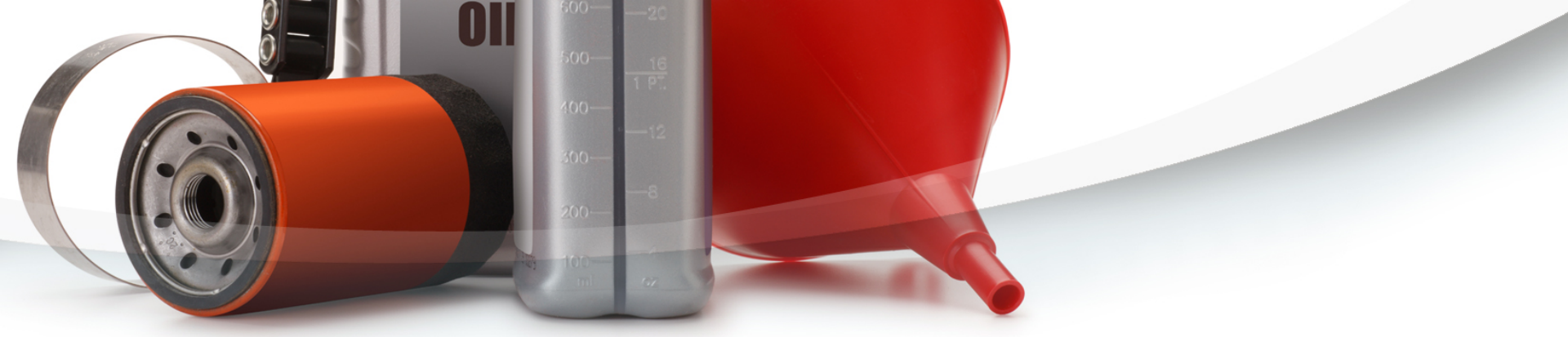

Hypothetical Policy Scenarios

- Table and Graphs
  - Reversed outputs for scenarios 9 and 10
  - Figure 5 – clarity not emphasis
- Scenarios 2, 3, and 4
  - Environmental and economic benefits greatest in scenario 4
  - Dependent on price elasticity assumption

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Interpretation Issues

- Combustion Modeling
- Confidential Data
- Benefits Transfer
- Toxicity Impact Assessment
- Primary Petroleum Refining
- Uncollected Oil

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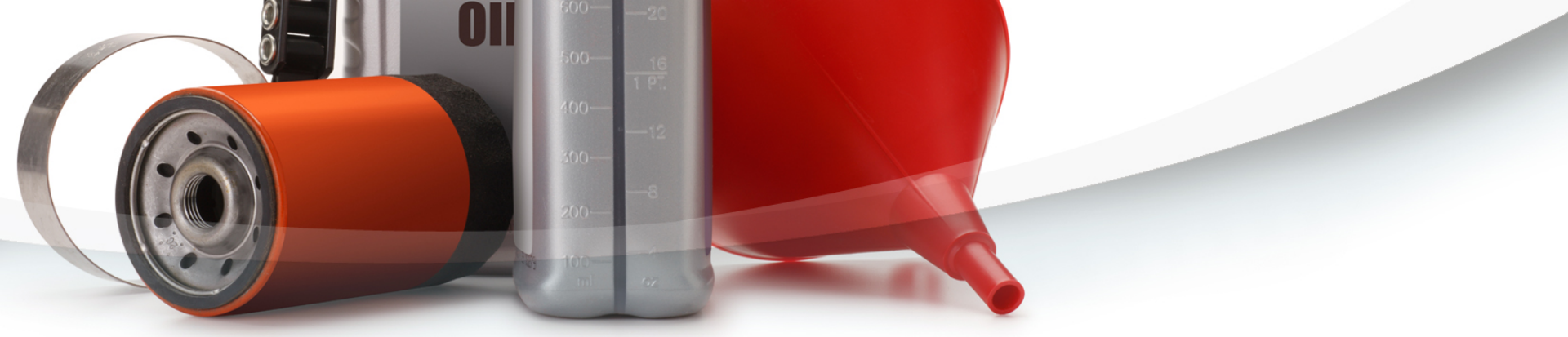

Used Oil Composition

- Preliminary data – Continuing Efforts
  - Howard Mayo
  - Dave Gorton
  - Belinda Barlow
  - DK, Evergreen, Safety-Kleen, Crystal Clean

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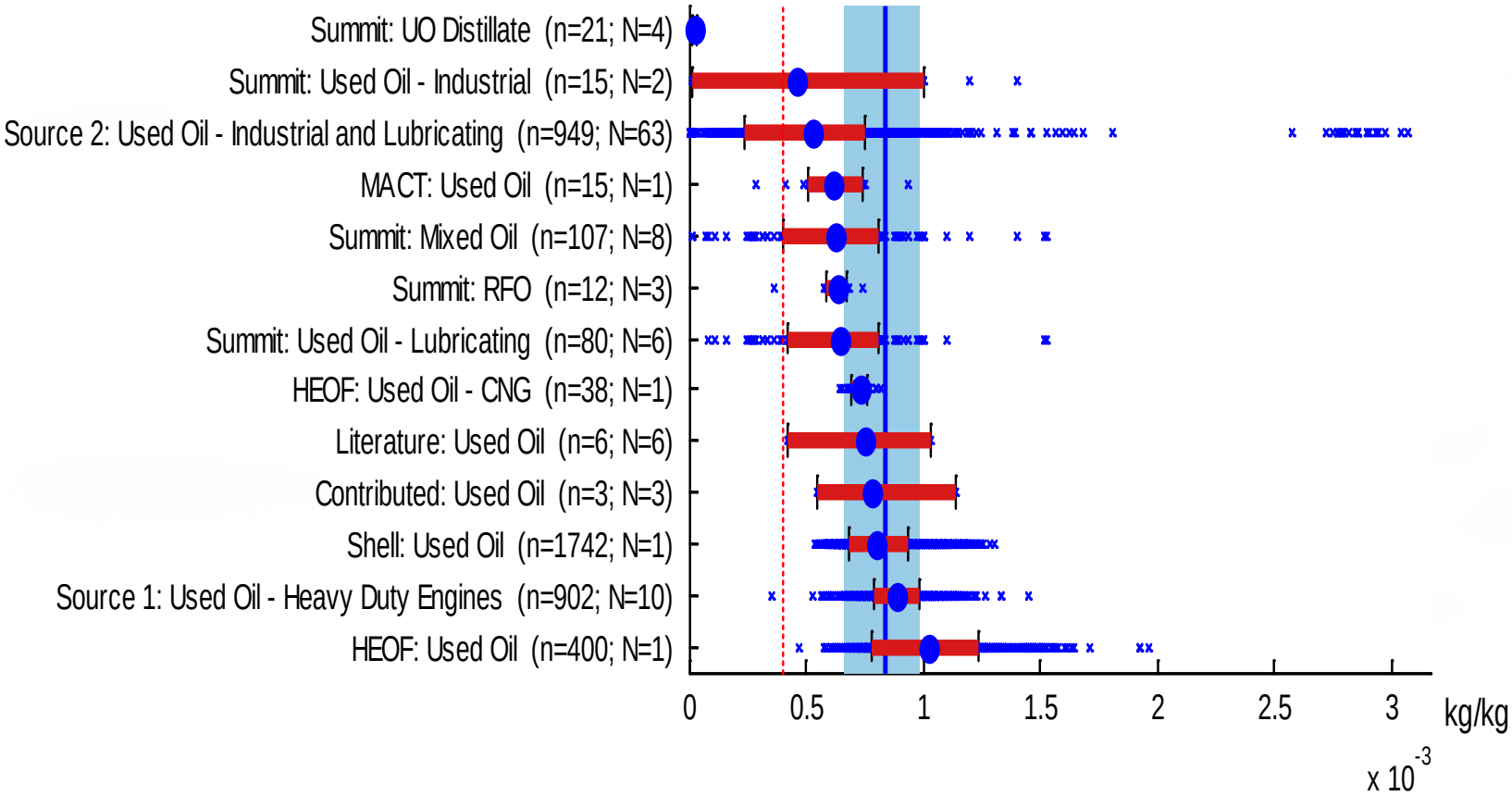
Phosphorus by Comp_Index - Phosphorus



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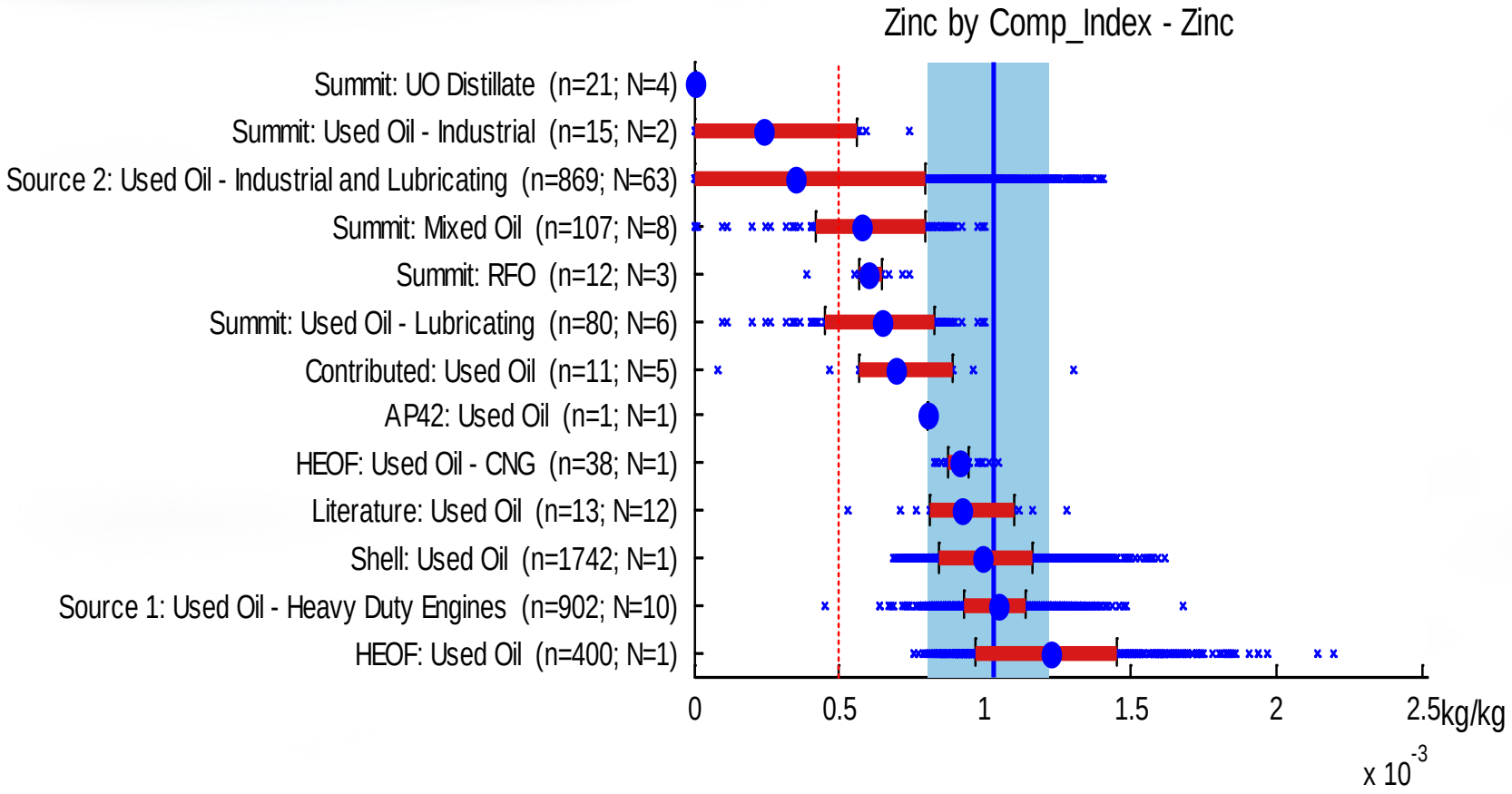
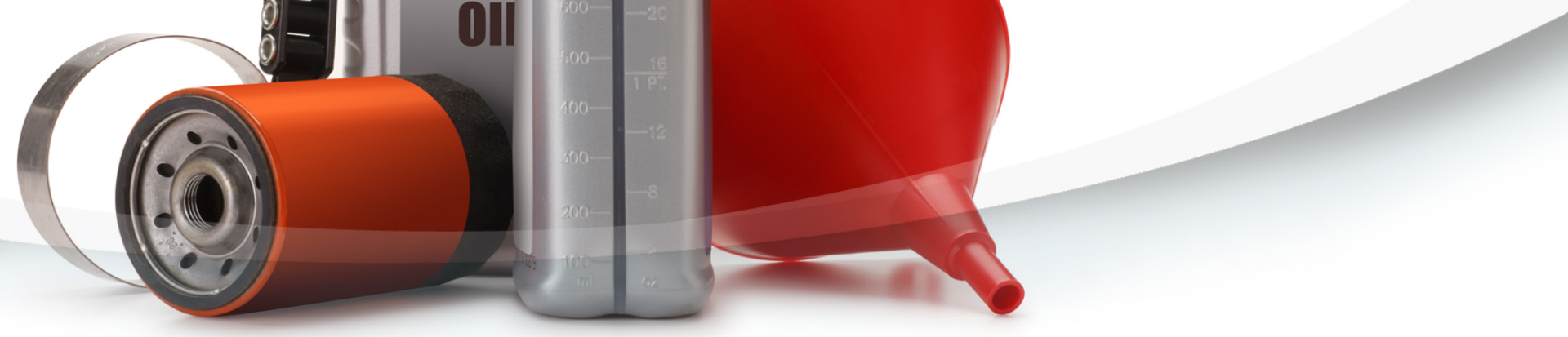
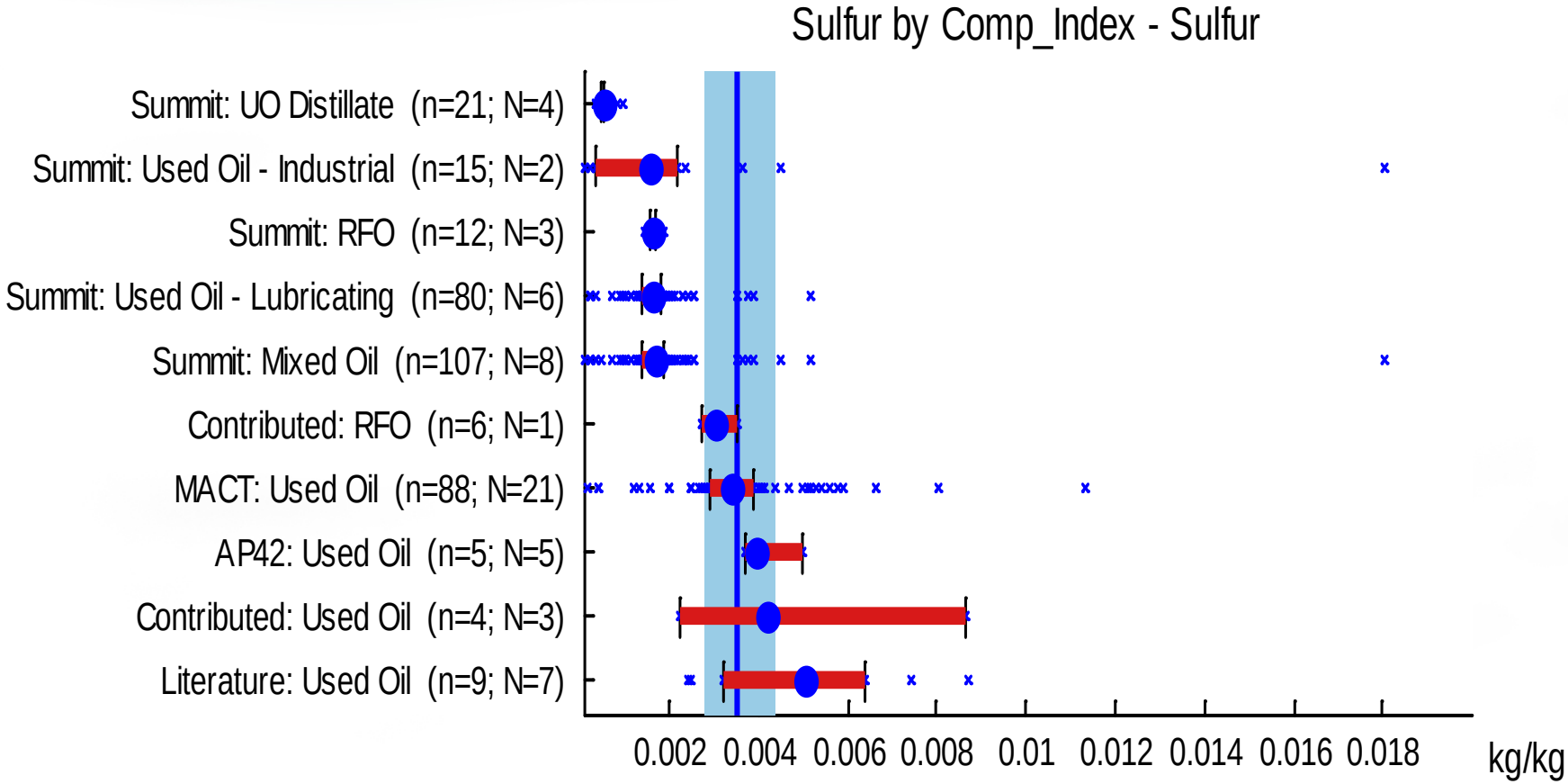

Zinc by Comp_Index - Zinc
Summit: UO Distillate (n=21; N=4)
Summit: Used Oil - Industrial (n=15; N=2)
Source 2: Used Oil - Industrial and Lubricating (n=869; N=63)
Summit: Mixed Oil (n=107; N=8)
Summit: RFO (n=12; N=3)
Summit: Used Oil - Lubricating (n=80; N=6)
Contributed: Used Oil (n=11; N=5)
AP42: Used Oil (n=1; N=1)
HEOF: Used Oil - CNG (n=38; N=1)
Literature: Used Oil (n=13; N=12)
Shell: Used Oil (n=1742; N=1)
Source 1: Used Oil - Heavy Duty Engines (n=902; N=10)
HEOF: Used Oil (n=400; N=1)
0
0.5
1
1.5
2
2.5kg/kg
x 10-3


OIL


Sulfur by Comp_Index - Sulfur
Summit: UO Distillate (n=21; N=4)
Summit: Used Oil - Industrial (n=15; N=2)
Summit: RFO (n=12; N=3)
Summit: Used Oil - Lubricating (n=80; N=6)
Summit: Mixed Oil (n=107; N=8)
Contributed: RFO (n=6; N=1)
MACT: Used Oil (n=88; N=21)
AP42: Used Oil (n=5; N=5)
Contributed: Used Oil (n=4; N=3)
Literature: Used Oil (n=9; N=7)
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
kg/kg

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Potential Policy Options

- Increase market value of used oil
- Decrease used oil generation
- Reduce use of used oil as RFO
- Targeted use of fees, incentives, etc
- Directly targeted efforts

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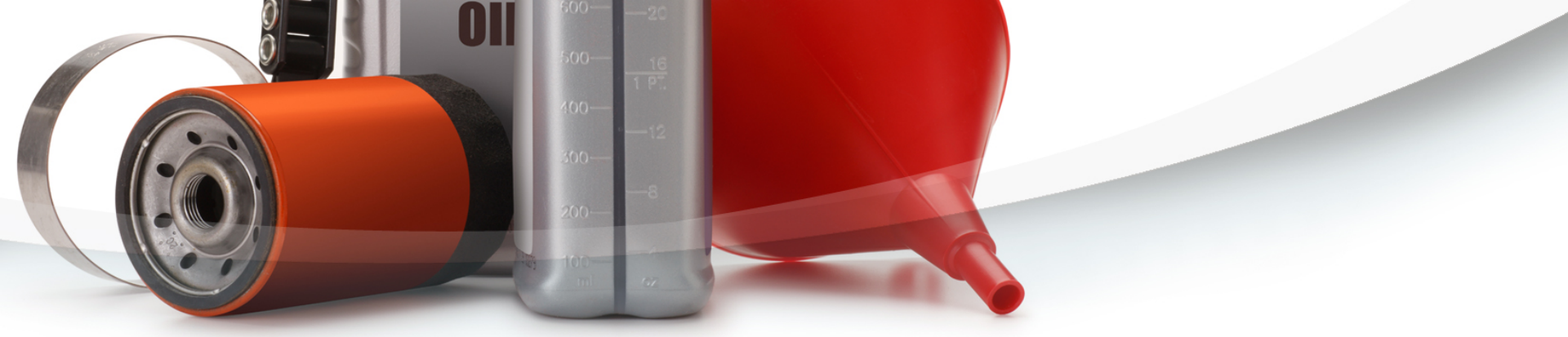

Potential Research Options

Planned

- Uncollected Oil Research
- Increased knowledge of industrial oils
- Increased collection opportunities and convenience
- Online tool
- High efficiency filters research
- “Check Your Number” campaign

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Potential Research Options

- Not yet planned
  - Enhanced combustion model
  - Enhanced primary refinery model
  - Behavioral/motivational research

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Next Steps

- Report to the Legislature
  - Due January 1, 2014

Questions and Comments

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