Société de gestion des huiles usagées (SOGHU)

Estimated Rates of Recoverable Antifreeze in Canada

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TABLE OF CONTENTS

TABLE OF CONTENTS

Tables

Figure

TABLE OF CONTENTS

Appendices

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Test results mentioned herein are only valid for the sample(s) stated in this report.

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SUMMARY

CONTEXT

In recent years, many provincial governments took measures using Extended Producer Responsibility (EPR) principles to ensure industry would take charge of recovering used oils and related materials (containers, filters, etc.). These initiatives, among others, led to the creation of provincial organizations, such as the Société de gestion des huiles usagées (SOGHU) in Quebec.

EPR principles are now being applied to glycol based antifreeze and cooling fluids; some provinces have already adapted their legislation and others plan to do so shortly.

The SOGHU and its partners in six other Canadian provinces have mandated that Dessau-NI Environnement estimate rates of potential recoverable antifreeze in each of the provinces.

METHODOLOGY

Dessau-NI Environnement first modeled the general patterns of use and disposal of new and used antifreeze. This involved identifying new antifreeze inputs, its uses, and the generators of used antifreeze, until its end-of-life. This isolated the values and data necessary to calculate the recoverable antifreeze rate.

Dessau-NI Environnement separates the market into three sectors:

- Automotive: passenger cars, light trucks (accidents taken into account, moderate use);
- Road transportation: trucks, buses (accidents taken into account, intensive use);
- Other sectors (Agriculture, Construction, Forestry, Mining, Oil and Gas, Utilities, Manufacturing): mainly heavy equipment (accidents not taken into account, intensive use).

The formula for calculating the rate of recoverable used antifreeze is as follows:

$$\frac{\textbf{Volume of recoverable antifreeze x concentration}}{\textbf{Volume of new antifreeze sold x concentration (50\%)}} \times 100\%$$

Where:

Volume of new antifreeze sold = sales of concentrate (A) + addition of water (C) + sales of premix (50/50, B) + antifreeze in vehicles sold (50/50), (E)

Concentration = average concentration of used antifreeze

And:

Volume of recoverable used antifreeze = drained antifreeze (M) + antifreeze in end-of-life vehicles and heavy equipment (N).

Dessau-NI Environnement identified two ways to determine the volume of recoverable antifreeze:

- Direct method, by draining: establishing recoverable volumes, mainly the volume of antifreeze drained and the volume of antifreeze remaining in end-of-life vehicles;
- Indirect method, by losses: losses of antifreeze from usage and caused by leaks or accidents are quantified. The volume of recoverable antifreeze corresponds to the difference between quantities sold and losses.

The direct method requires more precision from the automotive sector whereas the indirect method requires more precision from the "other sectors."[1]

DATA COLLECTION

Three methods of data collection were used, in descending order of accuracy:

- On-Field: concentration measures taken directly from used antifreeze samples;
- Analysis: statistical data from outside sources and statistical data generated by telephone surveys designed and conducted by Dessau-NI Environnement;
- Theory: field expert opinion, professional experience.

In order to have all the input necessary to calculate the rate of recoverable antifreeze, existing data from Statistics Canada, provincial statistics and statistics from specialized firms were gathered in addition to new information collected through telephone surveys of the identified sectors of automotive, road transportation and heavy equipment.

More than 2,600 companies were contacted by Dessau-NI Environnement to answer a questionnaire adapted to their business situation. Also, a sampling strategy was developed to collect used antifreeze samples in order to determine their glycol concentration. Sectors targeted are:

- Automotive garages and repair shops
- Road transportation sector
- Automobile recycling sector
- Other sectors (mining, farming, forestry, heavy industry).

From this, a global and representative picture of the different types of heavy equipment requiring antifreeze can be determined.

[1] i.e. mining, farming, forestry and heavy industry

After measuring and calculating the recoverable antifreeze volumes, glycol concentration was primarily determined by data acquired from collection companies and processors. The samples collected by the project team were also considered, although the sample's size diminishes its statistical value.

RESULTS

The table below shows the rates of recoverable antifreeze and absolute margins of error per province.

	BC	AB	SK	MB	ON	QC	NB
Direct method	47.6% ± 3.1%	41.7% ± 3.7%	43.7% ± 3.7%	46.9% ± 3.2%	47.2% ± 3.4%	43.7% ± 3.3%	45.0% ± 3.1%
Indirect method	45.0% ± 8.3%	38.5% ± 17.5%	39.9% ± 12.1%	44.4% ± 8.4%	44.5% ± 7.5%	41.5% ± 9.0%	43.4% ± 8.5%

The final margin of error was calculated by the statistical software CrystalBall using the margin of error obtained for each parameter. These margins of error were determined using the different values collected by the surveys and their variance.

For the direct method, margins of error were very satisfactory as they were between 3.1 and 3.7%, depending on the province. However, margins of error for the indirect method are less satisfactory (between 8.3 and 17.5%).

Hence, Dessau – NI Environnement recommends using results obtained through the direct method (drainage).

SENSITIVITY ANALYSIS

For British Columbia, Alberta and Saskatchewan, parameters of the "other sectors" contributed the most to the margin of error. For Manitoba and New Brunswick, parameters for road transportation are the ones which contributed the most. For Ontario and Quebec, parameters for the automotive sector have the most important contribution in the Direct Method. For the Indirect Method, the "other sectors" parameters were preponderant for Ontario, while road transportation parameters were preponderant in Quebec.

For the majority of provinces, the three most contributing parameters to the margin of error are:

- Direct Method :
  - Percentage of antifreeze drained in relation to consumed – heavy equipment (represents 29.9% of the margin of error on average)
  - Percentage of antifreeze drained in relation to consumed – trucks (represents 19.5% of the margin of error on average)

- Volume of antifreeze recovered in end-of-life light trucks and automobiles (represents 9.3% of the margin of error on average)

- Indirect Method :
  - Volume consumed by truck (represents 19.3% of the margin of error on average)
  - Volume consumed by heavy equipment – construction (represents 17.4% of the margin of error on average)
  - Top-up volume by truck (represents 13.0% of the margin of error on average)

RECOMMENDATIONS

For future studies, Dessau-NI Environnement recommends increasing the amount of data collected in order to increase the precision of the key parameters.

For the automotive sector, sampling antifreeze drained in garages may improve the precision of drained recoverable volume compared with total capacity.

With regards to used antifreeze, on-going measurements through the current recovery programs will allow potential calculation updates if values found were to be significantly different from the one used in this report (45%).

Updates on the number of heavy equipment in the 7 provinces would also have to be considered if any new data were identified or made available by the provinces or Statistics Canada.

Finally, Dessau - NI Environnement recommends updating the recoverable antifreeze rate once every five years in order to take into account future technological improvements, maintenance habits and environmental constraints.

GLOSSARY

Concentrate: Pure antifreeze that has to be diluted with water before usage

Desrosiers : DesRosiers Automotive Consultants Inc., consultants firm specialized in automotive market study.

DIFM: Acronym for “Do it for me”. Refers to a professional doing the drainage of the antifreeze.

DIY: Acronym for “Do it yourself,” refers to an individual with automotive mechanical competence, draining the antifreeze.

Direct Method (drainage): Method of calculating, consisting of evaluating the volume of recoverable antifreeze based on volume from drainages.

Indirect Method (losses): Method of calculation, consisting of evaluating the volume of recoverable antifreeze by subtracting the volume of losses from sales.

EPR: Extended Producer Responsibility

GDP: Gross Domestic Product

LT: Light truck; **LV:** Light vehicle

OEM : Original equipment manufacturer. Refers to manufacturers of cars, trucks and other vehicles and equipment included in this study

PC: Passenger car

Polk : R.L. Polk & Co., consulting firm specialized in truck market.

Pre-mix: Antifreeze sold diluted with water, having generally,a glycol concentration of 50%

Other Sectors: This denomination throughout this study groups together the mining, heavy equipment (notably the construction industry) and agriculture sectors.

Refractometer: Measuring tool used to determine the concentration of a solution. It is used to evaluate the degree of concentration of glycol in used antifreeze

SAAQ: Société de l’assurance automobile du Québec (Quebec government office responsible for vehicle licencing)

Top-up: Quantity of antifreeze added to a radiator in order to replace liquid lost through usage or leaks.

WARNINGS AND LIMITATIONS

Our objective was to minimize the margin of error for each statistic found and to optimize the sampling approach. Margins of error found are, for the most part, acceptable, especially in terms of overall results.

However, it was not possible to reach an acceptable margin of error for certain data; therefore they must be used with all due precautions.

Several biases in the study itself could influence the results. Notably, physical samples were collected at a particular time of year. The results could vary if samples had been taken at other times of the year.

In addition, as the participants sent samples themselves through the mail, we were not able to scientifically control the process of sampling.

Data sometimes came from companies' agglomerated accounting or environmental data sets. We tried to minimize biases related to unrecorded external purchases or inventory, but our data may not reflect all situations as they really exist.

The tables were set-up with data calculated by decimal, but non-round numbers were used in calculations.

Polk and Desrosiers data are licensed data. They are confidential and must not be used for other purpose that this study.

1 CONTEXT OF THE STUDY

1.1 OBJECTIVE

The product studied is glycol-based antifreeze (also called coolant), serving to cool thermal systems by transporting and evacuating heat from the system. The antifreeze is sold in different formats, in individual containers or in bulk and in different concentrations: pre-mix, which is ready-to-use (50/50 diluted glycol) and concentrated, which must be diluted with water for use.

With extended producer responsibility (EPR) now being applied to antifreeze, manufacturers have new responsibilities regarding antifreeze and the provinces must be able to evaluate with accuracy the volume of antifreeze that is recoverable, in order to measure the effectiveness of the programs and their recovery rate.

Consequently, the SOGHU for Québec and New-Brunswick and its partners in five other provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick) asked Dessau – NI Environnement to propose a methodology to determine the rate of recoverable antifreeze which is reliable, precise and amenable to all parties.

1.2 STATUS REPORT FOR EACH PROVINCE

Each of the seven provinces studied are at different stages regarding their EPR programs. Here is a brief overview of the situation.

British Columbia and Manitoba implemented an EPR program in July 2011 and Quebec in July 2012. These programs address automotive antifreeze (in individual containers or in bulk) for cooling thermal motors. Ontario implemented a similar program in 2008 only for antifreeze sold in containers.

Alberta does not currently have a program but plans to implement one in the near future. Saskatchewan and New Brunswick do not have programs currently, but are anticipating implementation by 2013.

2 METHODOLOGY

Before elaborating on the strategy used to collect the data, Dessau-NI Environnement considered and reviewed the parameters that would influence the calculation of the amount of recoverable antifreeze in order to determine the most efficient methods for data collection.

This was done in two stages, described in the next two sections:

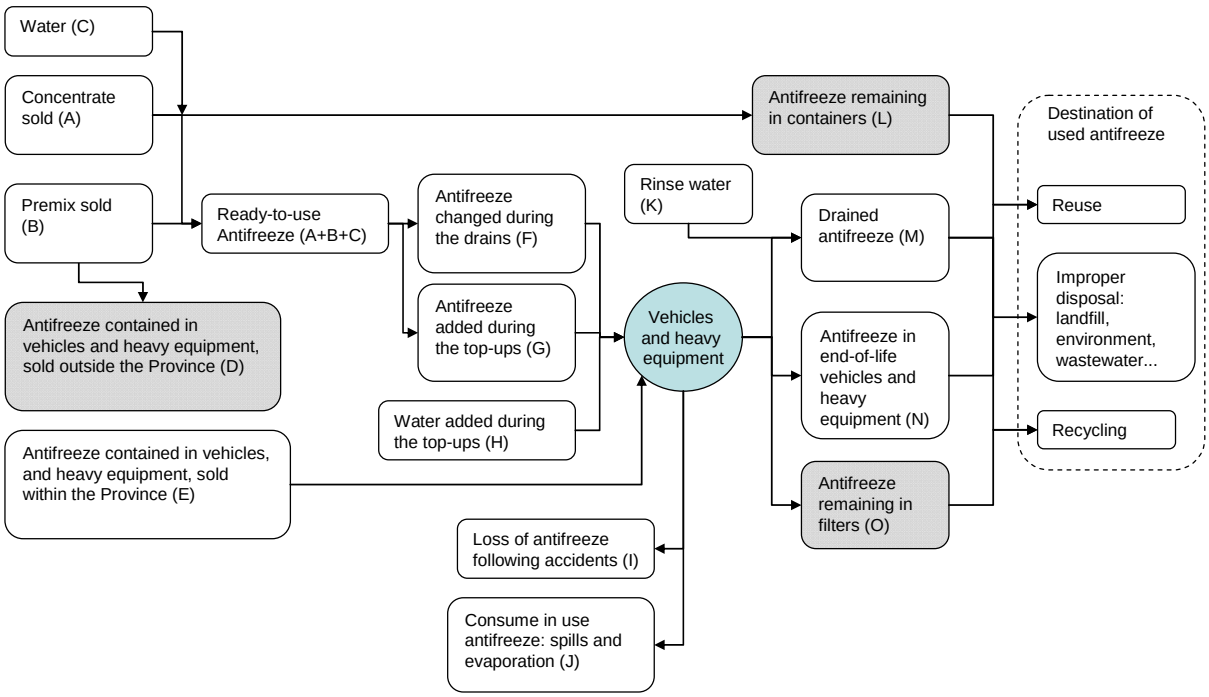
1- The first step was to establish the general life cycle of new and used antifreeze.

2- The second step was to discuss on the methods for calculating the parameters and the initial collection of the data, allowing for these calculations.

2.1 CHART OF ANTIFREEZE LIFE CYCLE AND VARIABLES IDENTIFICATION

In order to identify the parameters needed the team gave considerable thought to the flowchart. This involved identifying the uses of new antifreeze and the sources of used antifreeze, until its final destination (here named, end-of-life). Figure 1 shows the flow of new and used antifreeze and the data that needs to be researched.

Figure 1 Antifreeze flows before and after use



In the course of its life, the concentration of antifreeze can fluctuate, by adding water or concentrate during top-ups, by water evaporation and by rinsing of radiator after draining it. In order to take this into consideration, it was decided to calculate the rate of recoverable antifreeze at a concentration of 50/50. This is the traditional concentration of new antifreeze. It will be necessary to determine the average concentration of recoverable used antifreeze.

The table below represents the different parameters to be studied in the report. Those found to be insignificant will not be studied further.

Table 1 Description of the blocks forming the antifreeze flow pattern and preliminary identification of required data

BLOCK	DESCRIPTION OF THE PARAMETER	REQUIRED DATA
A, B	Volume of concentrate and premix antifreeze sold	Sales data
C	Water added to the concentrate	In amounts equal to the concentrate (50/50)
D	Antifreeze in vehicles and heavy equipment sold outside the province	Excluded, because these are not recorded in the sale of recoverable antifreeze
E	Antifreeze in vehicles and heavy equipment sold within the province	Number of vehicles involved, technical ratios
F	Antifreeze changed during drains	Volume of antifreeze changed during antifreeze drains, frequency of drains
G	Antifreeze added during top-ups	Volume of antifreeze added between antifreeze changes
H	Water added during top-ups	Volume of water added between antifreeze changes
I	Loss of antifreeze following an accident	Number of accidents involving antifreeze spills and quantities lost
J	Consume in use antifreeze	Spills and evaporation, equivalent to top-ups
K	Rinse water for cleaning after drains	Survey on habits, dilution rates of used antifreeze
L	Antifreeze remaining in containers	Considered negligible, as in the study on oil
M	Drained antifreeze	Volume of antifreeze recovered during drains
N	Antifreeze in end-of-life vehicles and heavy equipment	Number of vehicles and heavy equipment involved, technical ratios
O	Antifreeze remaining in filters	Considered negligible, as in the study on oil

This study does not intend to quantify used antifreeze volumes in terms of their end-of-life destination other than recovery, such as landfills, unconventional reuse or rejects in the environment. These quantities could be evaluated in a further study in order to evaluate estimated recoverable quantities.

2.2 SECTORS AND VARIABLES IN RECOVERABLE ANTIFREEZE DATA COLLECTION

Figure 1, page 9 shows the reference parameters. Losses from accidents represent a greater volume in this study that in the project for used oils. This affects principally cars and trucks. The market was therefore divided into three sectors:

- Automotive: passenger cars, light trucks (moderate use, accidents taken into account);
- Road transportation: trucks, buses (intensive use, accidents taken into account);
- Other sectors (Agriculture, Construction, Forestry, Mining, Oil and Gas, Utilities, Manufacturing): mainly heavy equipment (intensive use, accidents not taken into account).

The automotive sector includes all types of passenger cars and class 1 and 2 light trucks. The road transportation sector includes companies that transport passengers or freight. Vehicles in this category are heavy trucks and buses. The last sector contains the balance of all vehicles not in the two previous groups, such as tractors, loaders, excavators, bulldozers and lift trucks. Given the number of vehicles in the off-road sector, it was decided they should be divided into three subsectors:

- Agriculture : heavy equipment generally of smaller size
- Forestry, construction, municipal, industrial: medium sized heavy equipment.
- Mining, petroleum and gas: large sized heavy equipment.

2.3 FORMULA FOR CALCULATING RATE OF RECOVERABLE ANTIFREEZE

The formula for calculating the rate of recoverable used antifreeze is:

$$\frac{\textbf{Volume of recoverable antifreeze x concentration}}{\textbf{Volume of new antifreeze sold x concentration (50\%)}} \times 100\%$$

Where:

Volume of new antifreeze sold = sales of concentrate (A) + addition of water (C) + sales of premix (50/50, B) + antifreeze in vehicles sold (50/50), (E)

Concentration = average concentration of used antifreeze

And:

Volume of recoverable used antifreeze = drained antifreeze (M) + antifreeze in end-of-life vehicles and heavy equipment (N)

2.4 METHOD OF CALCULATION FOR AMOUNT OF RECOVERABLE ANTIFREEZE

Dessau-NI Environnement identified two ways to determine the volume of recoverable antifreeze:

- Direct method by draining: it entails establishing recoverable volumes, principally drained antifreeze and the antifreeze remaining in end-of-life vehicles.

- Indirect method, by losses: sources for loss of antifreeze are quantified, those being quantities lost from usage or accident or leaks. The volume of recoverable antifreeze corresponds to the difference between quantities sold and lost.

The direct method requires detailed information on the automotive sector. The indirect method requires more precision concerning “other sectors”.

The details for the calculations are detailed below for each sector.

2.4.1 Automotive Sector

2.4.1.1 Direct Method (draining)

Three values are necessary for calculating:

- The volume emptied: calculated by multiplying the frequency of draining (Desrosiers), the number of vehicles (Desrosiers) and the average volume drained (according to the surveys and Desrosiers).
- The volume collected after a repair or a radiator change: calculated by multiplying the number of vehicles in circulation (Desrosiers) by the frequency of repairs (Desrosiers) and the average volume recovered, as a result of this procedure (according to the survey).
- The volume recovered from end-of-life vehicles: number of end-of-life vehicles (calculated by subtracting sales from the increase in number of vehicles, according to Desrosiers) multiplied by the average volume recoverable in an end-of-life vehicle (according to survey done with recyclers).

The sum of these three values equals the total volume of recoverable antifreeze. It is by putting this value in relation to the volume of antifreeze in the marketplace that the rate of recoverable antifreeze can be calculated.

2.4.1.2 Indirect Method (losses)

The Indirect Method is slightly more complex and involves determining losses due to usage and leaks. In order to determine the volume of recoverable antifreeze, the volume of antifreeze sold must be added to the volume in end-of-life vehicles and the total losses must be substracted from the total.

The volume of losses due to usage are calculated by determining the volume consumed at “do-it-yourself” top-ups (DIY, includes those with mechanical knowledge, the frequency is taken from Desrosiers statistics) and the volume consumed by “do-it-for-me” top-ups (DIFM, involves a professional, evaluated by surveys done with garages). DIFM and DIY top-ups are calculated by multiplying the frequency of top-ups with:

- the number of vehicles: according to the statistics by Desrosiers
- the respective proportion of DIY and DIFM

- the average volume of top-ups: evaluated from the surveys

Calculation also considered the volume of antifreeze missing when drained, because owners do not do top-ups if they drain their antifreeze. This value is calculated by multiplying:

- the frequency of draining: according to statistics by Desrosiers
- the average volume for a top-up: according to the surveys
- the number of vehicles: according to statistics by Desrosiers

The calculation of losses due to leaks is the product of:

- the frequency of radiator repairs: taken from statistics by Desrosiers
- the number of vehicles: according to statistics by Desrosiers
- the average volume recovered from a replaced radiator: according to the surveys

2.4.1.3 Volume of Antifreeze Sold

Two values are necessary to make this calculation:

- the volume of antifreeze sold: calculated by adding the volume of antifreeze for top-ups and leaks and the volume of antifreeze used for drainage.
- the volume coming from light vehicles in the marketplace (OEM): calculated by multiplying the average volume of antifreeze in the vehicles (Desrosiers) and the number of vehicles sold (Desrosiers).

2.4.2 The Road Transportation Sector

2.4.2.1 Direct Method (drainage)

To obtain the amount of recoverable antifreeze with this method, the calculation is similar to that of the automotive sector. To obtain the volume from drainages, two values must be multiplied:

- proportion of the recoverable volume compared to the volume consumed: according to the surveys
- volume consumed: multiplication of the number of trucks (according to the statistics by Polk) by the volume of antifreeze consumed per truck (according to the surveys).

The result is added to the volume of antifreeze in end-of-life vehicles, obtained by multiplying:

- number of trucks at end-of-life: calculated by subtracting the increase of the number of vehicles from sales
- volume recovered from end-of-life trucks: according to recyclers surveys

2.4.2.2 *Indirect Method (losses)*

It is necessary to know the volume of total losses, which corresponds to the sum of losses due to leaks (accidental or mechanical breaks) and those due to usage. Once this variable is known, antifreeze losses must be subtracted from volumes sold and in end-of-life vehicles in order to know the volume (and the rate) of recoverable antifreeze.

Losses due to accidents are the result of multiplying:

- the number of damaged vehicles: according to provincial statistics and the hypothesis that 50% of radiators are damaged in an accident.
- the average volume of antifreeze losses: corresponds to the difference between the average volume of antifreeze in a truck (obtained by research and surveys) and the remaining volume left in the damaged radiator (according to the surveys done with transporters).

For losses due to mechanical breakage, the average annual volume of losses following a breakage (evaluated from survey answers) must be multiplied by the number of trucks in circulation (Polk).

The calculation for losses due to usage requires multiplying the average annual volume of top-ups (according to surveys) with the total number of trucks and buses (according to statistics by Polk).

2.4.2.3 *Volume of Antifreeze Sold*

Two values are necessary for making this calculation

- the volume of antifreeze sold: calculated by multiplying the average volume of antifreeze consumed (surveys) and the number of trucks in circulation (Polk).
- the volume from trucks in the marketplace (OEM): calculated by multiplying the average volume of antifreeze in trucks (research and surveys) by the number of trucks sold annually (Polk).

2.4.3 Other Sectors

As previously mentioned, this sector is the accumulated data collected for the mining, oil and gas, forestry, agriculture, municipal, construction, and manufacturing sectors. The equipment using antifreeze is referred to as “heavy equipment” in this study.

2.4.3.1 *Direct Method (drainage)*

The calculation method is identical to that used in the transportation sector. It consists of calculating the total volume drained for the heavy equipment sector (volume consumed multiplied by the percentage of recoverable antifreeze, obtained through the surveys) and adding it to the volume coming from end-of-life heavy equipment.

2.4.3.2 *Indirect Method (losses)*

Accidents are not taken into consideration for “other sectors.” Therefore, the volume of total losses is calculated by adding losses due to leakages and those due to usage.

The survey allowed to quantify the average volume of antifreeze lost due to breakages, and the volume of top-ups per heavy equipment (corresponding to losses by usage).

These values are multiplied by the number of heavy equipment (estimated). The result is then subtracted from the volume of antifreeze in sold heavy equipment and the volume remaining in end-of-life heavy equipment to obtain the value needed.

2.4.3.3 Volume of Antifreeze Sold

Two values are necessary to make this calculation:

- The volume of antifreeze sold: calculated by multiplying the average volume of antifreeze consumed per heavy equipment (surveys) and the number of heavy equipment in circulation (estimated).
- The volume of antifreeze from heavy equipment sold (OEM): calculated by multiplying the average volume of antifreeze in the heavy equipment (research and surveys) and the number of heavy equipment sold per year (estimated).

2.4.4 Overall Calculation

The overall calculation consists of adding the volumes of recoverable antifreeze per sector to the volumes in the marketplace, per sector.

It should be noted that recoverable antifreeze volumes are adjusted to equal a concentration of 50%, the normal concentration for pre-mix.

3 ELABORATION AND IMPLEMENTATION OF RESEARCHED INFORMATION

The planning and implementation of the data research was divided into three principle stages:

- Stage 1: identify the key variables and determine the way to quantify them
- Stage 2: identify all the parameters that might influence the key variables or the mathematical equations used to determine the rate of recoverable antifreeze
- Stage 3: design and execute the sampling protocol

3.1 METHOD FOR DATA COLLECTION

Three data collection methods were used, in decreasing order of accuracy:

1. In the Field: onsite measurement of antifreeze concentrations from samples
2. Analytics: statistical data coming from outside sources and from telephone surveys created and conducted by Dessau-NI Environnement
3. Theory: expert advice, professional experience

3.2 SOURCES OF DATA NECESSARY FOR CALCULATIONS AND PERTINENT VARIABLES

In order to have all the information necessary to calculate precisely the rate of recoverable antifreeze, it was necessary to use existing input from Statistics Canada, provincial statistics and statistics from specialized firms; and to acquire new data through telephone surveys reaching out to the identified sectors of automobile, road transportation and heavy equipment.

Specialized market research firms provided information on the automotive sector (Desrosiers) and on trucks (Polk). This allowed Dessau-NI Environnement to present more accurate results and to complete the study while respecting deadlines.

For several years, Desrosiers has been carefully compiling data by province on the number of PCs and LTs, the annual sales of vehicles, antifreeze and radiators, maintenance habits, volume of fluids by type of vehicle and for every model.

For the truck sector, Polk makes details available on the number of trucks in circulation, by class (3 to 8) and by model. Statistics Canada's data was not used, because the numbers of trucks sold and in circulation are not detailed enough.

The data collected in the survey was treated universally across Canada with the same values in every province. There was nothing to indicate that the parameters would be different from one province to another.

The parameters and their sources are detailed in Appendix 1.

3.2.1 Specific Data for Each Province

3.2.1.1 Number of Vehicles and Heavy equipment and Antifreeze Capacity for Light Vehicles

The number of vehicles in circulation (PCs, LTs, heavy trucks, and buses), annual sales (by type) and the antifreeze capacity of PCs and LTs (classes 1 and 2) come from the Desrosiers. This data was taken from provincial registries and is, therefore, very reliable.

The data on the number and the sales of heavy equipment come from the SAAQ and calculations. A margin of error of 20% was attributed to it.

Finally, the estimate for the number of end-of-life vehicles and different types of vehicles or heavy equipment come from Desrosiers, Polk and estimate. This data allows us to better understand the evolution of the quantity of vehicles and heavy equipment that use antifreeze by province for the purpose of this study.

3.2.1.2 Routine Maintenance of Light Vehicles

This concerns the number of radiators changed or repaired annually, the frequency of DIY top-ups, the frequency of drainage, and the proportion of DIFM. These parameters are from surveys done by Desrosiers with 2,500 Canadian consumers and are unique to each province.

The number of damaged trucks in accidents is supplied by provincial statistics.

3.2.2 Data Identical for the Provinces

3.2.2.1 Automotive Sector

The frequency of DIFM top-ups and the average volume for top-ups for PCs and LTs was estimated via telephone surveys done with garages. This data was not measured precisely by mechanics, whom gave only estimates. By accumulating a significant number of respondents, Dessau-NI Environnement targeted reducing the margin of error as much as possible.

The quantities remaining in a leaking radiator are calculated with the data collected in the surveys with auto body shops. The volume of antifreeze that remains in end-of-life vehicles is calculated with the data collected from surveys done with recyclers. This data was calculated using the annual volume of new and used antifreeze annually and the number of vehicles involved. Therefore, they are more accurate than estimates.

3.2.2.2 Road Transportation Sector

The road transportation sector includes heavy trucks and buses

The volume of antifreeze used for heavy vehicles classes 3 to 8 was estimated from the surveys and the information provided by technical specification sheets of vehicles of different classes.

In the same way as for cars, the volume remaining in the trucks and buses at end-of-life was estimated from surveys done with recyclers.

The volume lost due to leaks and the volume used for top-ups are based on estimates made by survey respondents.

Finally, the volume of new antifreeze consumed and that of used antifreeze are from the purchase and environmental registries of survey respondents.

3.2.2.3 Other Sectors

The volume of antifreeze contained in heavy equipment was estimated from the survey and study of specification sheets of heavy equipment from different sectors.

The volume remaining in end-of-life heavy equipment was estimated from that of trucks and prorated by their antifreeze capacity.

The volume lost due to leaks and the volume used in top-ups are estimations made by survey respondents.

Finally, the volume of new antifreeze consumed and that of used antifreeze are from the purchase and environmental registries of survey respondents.

3.3 TWO-PHASE APPROACH

Knowing the margin of errors in advance was not possible, therefore the study was done in two phases:

Phase 1

The first phase focused on the research of statistical data on all the provinces (directly and by market research firms, who already had a large quantity of data on the automotive and truck sectors).

The researched statistical information was:

- the number of vehicles in circulations
- the number of vehicles sold
- the number of vehicles at end-of-life
- the number of accidents
- the volume of antifreeze in LVs
- frequency of drainage and top-ups in the automotive sector.

At this stage, the surveys took place in Quebec among body shops, automotive garages, road transporters, collectors, car recyclers, and companies in “other sectors.”

After this first phase, it was possible to calculate the preliminary quantities of recoverable antifreeze for all provinces, by using specific statistical information for each province and the values from the surveys in Quebec. The statistical data from the samples and the margins of error reached in Phase 1 allowed for the key parameters to be set for Phase 2 in order to attain the most precision possible, satisfying all stakeholders.

Phase 2

This phase consisted in conducting in the other six provinces the same surveys and sampling methods used for Quebec. Certain adjustments were made to the samples sizes due to Phase 1 results analysis.

3.4 IMPLEMENTATION OF INFORMATION RESEARCH

3.4.1 Research of Statistical Data

All data concerning light vehicles and trucks was obtained through Polk and Desrosiers. Only data on the number of heavy equipment could not be obtained directly through the different provincial organizations. Lots of research have been done, and led to conclude that this type of information is simply not available. Even specialized consulting firms, like Yengst & Associates, did not have this type of information.

Only Quebec has a registry for all heavy equipment. Through analysis of the makes and models it was possible to classify the heavy equipment according to three sectors: agriculture, construction-forestry-manufacturing, and mining. The data for the other provinces was extrapolated from this data prorated from the GDP of the different sectors and provinces.

3.4.2 Samples of Used Antifreeze

3.4.2.1 Planning and Practice

Selection of Sample Areas

The sampling of antifreeze was done through survey respondents. In the confines of the survey, over 2,600 businesses were contacted. At the end of the questionnaire, all respondents were asked if they would supply a sample of used antifreeze. In Quebec, some sampling was done by Dessau-NI Environnement. Because of the costs and time needs associated with physically taking samples all across Canada, a postal method was implemented for the other provinces.

Organizing the Samples and Measuring Concentration

The sampling procedure involved sending a package containing an explanatory letter, a 50 ml vial and a plastic bag and a prepaid return envelope. The letter explained the required procedure: filling the vial to ¾ full and closing it, inserting the vial into the plastic bag and returning it within 24 hours in the prepaid envelope. The samples were then analyzed by a refractometer (Hanna HI 96831

model). As per the instruction manual, the instrument was washed then calibrated with distilled water. The water is removed with absorbent paper. A few drops of antifreeze are then placed on the reader of the instrument. After each reading, the surface is cleaned with distilled water. All steps are repeated for each test. The measure is a minimum of two times in order to avoid errors in reading. Pipettes are used to handle the antifreeze and are cleaned in distilled water between each reading in order to avoid cross-contamination. If oil is detected in a sample, the pipette is replaced so as to avoid any oil resistance to cleaning.

3.4.2.2 Results of the Sampling Plan

A total of 68 businesses (45 in Quebec, 23 in other provinces) provided a sample of used antifreeze.

3.4.2.3 Complementary Data Research

Some collectors were contacted and asked to sample the concentration of their used antifreeze. Their results were added to the data. This was done to compensate for the small number of samples obtained and to have more precise data on the concentration of ethylene glycol in used antifreeze.

In addition, BCUOMA in British Columbia holds approximately a hundred concentration measurements from different collectors since the start of their antifreeze recovery program. This data was also used.

3.4.3 Telephone Survey

Telephone surveys were conducted as follows. Companies or organizations were found through internet research, chamber of commerce lists, industrial associations or even, rarely, directly with business associations. These companies were then contacted by telephone. The professional conducting the survey identifies him/herself, explains the reason for their call, the goal of the study and that the study was requested by the concerned provincial association. The questionnaire was either filled-out immediately while on the phone, or emailed or faxed to the respondents. A copy of the letter of authorization signed by the provincial association representative was sent systematically with a fax or email questionnaire. Questions asked were to obtain the volume of antifreeze used and recovered in 2011, details about the vehicle inventory, or the quantity of heavy equipment and the procedure for the collection and storage of used antifreeze. Respondents were also asked for their agreement to supply a sample of used antifreeze. Different models of the questionnaires that were used are presented in appendix 19.

The type of companies contacted in Phase 2 was identical to those in Phase 1: road transportation, agriculture, forestry, industrial, mining, construction, public works, garages, body shops and recyclers.

More than 2,600 businesses were contacted by Dessau-NI Environnement and 478 surveys were completed, making the response rate 16%. The response rate varied between industries, as shown in Table 2. Some sectors like mining and forestry proved to be less willing to participate.

Table 2 Inventory of Telephone Surveys by Sector

SECTOR	NUMBER OF COMPANIES CONTACTED	NUMBER OF SURVEYS ANSWERED	RESPONSE RATE
Garages	504	127	25%
Body Shops	589	94	16%
Car Recyclers	123	48	39%
Road Transport Companies	812	128	16%
Other Sectors	582	81	14%
Agricultural	*127*	*20*	*16%*
Forestry	*115*	*9*	*8%*
Construction	*140*	*8*	*6%*
Industrial	*115*	*25*	*22%*
Municipal	*13*	*12*	*92%*
Mining, Oil an Gas	*72*	*7*	*10%*

Table 3 Inventory of Telephone Surveys by Province

PROVINCE	NUMBER OF COMPANIES CONTACTED	NUMBER OF SURVEYS ANSWERED	RESPONSE RATE
British Columbia	338	49	14%
Alberta	293	37	13%
Saskatchewan	215	30	14%
Manitoba	247	30	12%
Ontario	704	88	13%
Quebec	686	218	32%
New-Brunswick	127	26	20%

In 2010, Dessau – NI Environnement conducted a study for the SOGHU on the rate of recoverable used oil in Quebec. The companies that had participated in this project were contacted again to take part in the present study, explaining the higher response rate in Quebec.

4 RESULTS OF DATA COLLECTED

4.1 ANTIFREEZE CONCENTRATION MEASUREMENTS

The average of the 68 concentration measurements was 57.9%. This number is high in comparison to the data collected directly from collectors in Quebec and British Columbia.

It should be noted that of the businesses that sent a vial with an antifreeze sample, garages were over represented. This impacted the concentration of the used antifreeze. Mr. Éric Poisson, President of Global Récupération, said that it is not unusual for garages to have higher concentration levels, because some mechanics do not respect recommended dilution instructions. They are known to sometime add more concentrated antifreeze “just in case”, or to use concentrate antifreeze for top-ups.

Taking into account that samples taken by collectors correspond to large quantities of antifreeze and that they are much more representative of real levels, it has been decided to not take into account samples taken directly from generators. Only the data from the collectors in British Columbia (45.5%) provided by BCUOMA and in Quebec (44.4%) provided by Global Récupération have been used in calculations.

4.2 STATISTICAL DATA AND THE SURVEYS

The values used for calculations and the margins of error are indicated in Appendix 1.

4.3 HYPOTHESES AND METHODS OF CALCULATION

Foreseeing the difficulty in collecting data for certain parameters, it was necessary to propose some hypotheses in order to proceed with the calculations. The table below shows the principle hypotheses used, and details how to calculate certain parameters.

Table 4 Hypotheses and precisions

PARAMETERS	HYPOTHESIS AND DETAILS	COMMENTS
Number of heavy equipment by sector in Quebec	Dessau – NI Environnement analyzed 55% of the SAAQ files that grouped all the makes and models (about 60,000) of off-road vehicles. This allowed us to determine the number of heavy equipment per sector. Carts, ATVs and lawnmowers were excluded.	A 20% relative margin of error was used in calculations
Number of heavy equipment by sector and the sales for the other provinces	Calculated from data in Quebec prorated from the GDP by the sectors involved (See details on calculations in Appendix 2).	The data for makes and models did not exist for the other provinces because most heavy equipment is not registered. A 20%

PARAMETERS	HYPOTHESIS AND DETAILS	COMMENTS
		relative margin of error was used in calculations
Sale of heavy equipment by sector	Sale equivalent to the proportion of this type of heavy equipment in relation to the total number of heavy equipment	Data not available. A margin of error relative to 20% was used in calculations
Number of end-of-life vehicles and heavy equipment	Difference between annual sales and the increase of the quantity of vehicles	Data not available.
Volume of recoverable antifreeze in end-of-life heavy equipment.	Calculated from the volume in trucks at end-of-life prorated by the capacity of the heavy equipment.	Data not available.
Sale of vehicles, frequency of top-ups, frequency of radiator changes, frequency of drainage	Average of values 2006-2010	So as to smooth the variables that are sometimes raw
Average volume of antifreeze, light vehicles *Also for the average volume of antifreeze, light trucks*	Average volume calculated prorated by the number of cars, light trucks class 1 and 2.	-
Average volume of antifreeze, light vehicles sold *Also for the average volume of antifreeze, light trucks sold*	Average volume calculated prorated by the number of sold cars, light trucks class 1 and 2.	-
Average volume drained, light vehicles	Calculation from the average volume capacity minus the average top-up volume, supposing the top-up is not done when drainage is foreseeable.	Data not available
Average volume of antifreeze, trucks sold *Also for the average volume of antifreeze, trucks sold*	Average volume calculated from average volume of the different classes prorated by the number of trucks, class 3 to 8.	-
Average volume of antifreeze, consumed by trucks 3 to 6 *Also for the average volume lost due to leaks and the volume of top-ups, light trucks sold*	Parameters concerning trucks classes 3 to 6 were calculated from data on trucks classes 7 to 8 prorated by the capacity in antifreeze	Data obtained by survey concerning principally trucks classes 7 and 8
Number of truck radiators broken in accident	Due to this parameters small impact on the results, the hypothesis that 50% of trucks that had accidents, had radiator leaks.	Data not available
Average volume of antifreeze heavy equipment *Also for the average volume of antifreeze, heavy equipment sold*	Average volume calculated from average volumes of different categories of heavy equipment and prorated by the number of heavy equipment per category	-
Volume left in end-of-life heavy equipment	Calculated by the volume left in end-of-life trucks, prorated by their capacities	Data not available

5 CALCULATION OF RECYCLABLE ANTIFREEZE

5.1 RESULTS

Dessau-NI Environnement designed the formula for calculating overall rates. The 67 parameters used, their values and their precision are shown in Appendix 1. The comparable results are detailed in Appendix 3; and the detailed calculations for each province in Appendices 4 through 10.

Table 5 Rates of Recoverable Used Antifreeze and Absolute Margins of Error

	BC	AB	SK	MB	ON	QC	NB
Direct method	47.6% ± 3.1%	41.7% ± 3.7%	43.7% ± 3.7%	46.9% ± 3.2%	47.2% ± 3.4%	43.7% ± 3.3%	45.0% ± 3.1%
Indirect method	45.0% ± 8.3%	38.5% ± 17.5%	39.9% ± 12.1%	44.4% ± 8.4%	44.5% ± 7.5%	41.5% ± 9.0%	43.4% ± 8.5%

The differences between the provinces are due to 2 principal factors:

- The relative weight of the three sectors which have different rates. Provinces with large “other sectors” have lower rate than the others
- The maintenance habits for the automotive sector: the frequency of top-ups and drainage. A province with a higher frequency of drainage will have a higher rate

The difference between Ontario and Quebec rates appears a good example to show how those factors interact. Although the difference between the Ontario rate (47.2%) and Quebec rate (43.7%) may not be explained by looking at both provinces’ similar rates for road transportation sector (34.4% and 34.3%) and the other sectors (33.3% for both), rates for the automotive sector are different (56.7% for Ontario and 53.2% for Quebec) due to different habits in the frequency of drainage (17.4% in Ontario and 14% in Quebec). The fact that the automotive sector represents 58% of the antifreeze sales in Ontario compared to 51% in Quebec further add to this sector’s importance in explaining the difference between the two provinces.

The margins of error for the Direct Method (by drainage), 3.1 to 3.7% depending on the province, are very satisfactory. However, the margins of error for the Indirect Method are less satisfactory, between 8.3 and 17.5%, depending on the province.

It was suggested that the objectivity (and the accuracy) of the information supplied was greater in the Direct Method, because they are actually recorded numbers, unlike the Indirect Method, where many of the parameters are the opinions given by the survey respondents.

The margin of error for the Indirect Method (losses) is higher for provinces with a large mining, oil and gas sector, like Alberta and Saskatchewan. The parameters in this sector have a high margin of error, due to the small number of reliable respondents in this sector.

Dessau – NI Environneemnt recommends using the results of the Direct Method (drainage) because the margins of error are better than those by the Indirect Method.

5.2 MARGIN OF ERROR

5.2.1 Method of Calculation for the Margin of Error

CrystalBall, a statistical analysis software, was used to calculate the final margin of error from the margins of error for each parameter. These margins of error were calculated from all the data gathered in the study and their variances.

The software uses the formula used to calculate the rate of recoverable antifreeze. It does 5,000 iterations, changing variables' value in the formula each time. The value of each parameter is changed to a random value within its margin of error. The software then analyses the thousands of iterations and their results to calculate a global margin of error. The CrystalBall reports are shown in Appendices 11 through 17 for the different provinces and for each of the two methods.

It is important to mention that the value of the margin of error obtained this way is the maximum one. The selected value for a parameter is as likely to be at the extremities of the confidence interval as it is to be at the centre of the distribution curve. However, in many cases, the distribution curve is more a "normal distribution", meaning that it is more probable that the value be near the mean.

5.2.2 Sensitivity Analysis

The CrystalBall software also provides a sensitivity analysis. This helps to determine the variables that influence the precision the most, identifying parameters that would need greater attention in future studies.

The Tables 6 and 7 represent the contributions to the margin of errors for the three sectors. Only parameters having an influence of over 0.5% were taken into account. The results for all the parameters are shown in Appendix 18.

Table 6 Contribution by Parameters to the Margin of Error for the Direct Method

	BC	AB	SK	MB	ON	QC	NB
Automotive	28.7%	7.8%	6.6%	23.7%	43.8%	40.1%	33.9%
Road transportation	25.8%	17.5%	19.9%	36.8%	24.0%	32.7%	42.4%
Other sectors	43.6%	73.1%	69.1%	35.9%	31.1%	25.4%	21.4%

Table 7 Contribution by Parameters to the Margin of Error for the Indirect Method

	BC	AB	SK	MB	ON	QC	NB
Automotive	2.8%	0.0%	0.5%	1.7%	8.4%	5.2%	1.6%
Road transportation	29.4%	11.1%	26.2%	60.1%	41.2%	52.0%	60.3%
Other sectors	57.5%	87.2%	65.6%	29.7%	47.8%	39.8%	34.5%

For British Columbia, Alberta and Saskatchewan, the parameters of the other sectors contribute the most to the margin of error.

For Manitoba and New Brunswick, it is the parameters for road transportation that contribute the most.

For Ontario and Quebec, parameters for the automotive sector have the greater impact for the Direct Method. For the Indirect Method, the parameters of the other sectors are predominant in Ontario, while road transportation parameters are predominant in Quebec.

For the majority of provinces, the three main contributing parameters to the margin of error are:

- For the Direct Method:
  - Percentage of antifreeze drained in relation to consumed – heavy equipment (represents 29.9% of the margin of error on average)
  - Percentage of antifreeze drained in relation to consumed – trucks (represents 19.5% of the margin of error on average)
  - Volume of antifreeze recovered in end-of-life light trucks and automobiles (represents 9.3% of the margin of error on average)
- Indirect Method :
  - Volume consumed by truck (represents 19.3% of the margin of error on average)
  - Volume consumed by heavy equipment – construction (represents 17.4% of the margin of error on average)
  - Top-up volume by truck (represents 13.0% of the margin of error on average)

5.3 VOLUME OF ANTIFREEZE SOLD

The method used in the current study calculates the volume of antifreeze sold for top-ups and fluid changes. It is interesting to compare these results to those obtained through surveys or estimations based on sales reports.

Table 8 Comparison of Volumes Sold for the Method Used and the Estimations per Provinces

	BC	AB	SK	MB	ON	QC	NB
Volume estimated by surveys or extrapolated from sales declarations	10,128,440	18,850,576	3,424,040	4,521,000	26,611,061	18,598,120	ND
Sources	Extrapolation from declarations of sold antifreeze during 6 months in 2011	2008 and 2010 AUOMA Surveys	SARRC Survey	Extrapolation from declarations of sold antifreeze during 4 months in 2011	Extrapolation from declaration of packaged antifreeze sold in 2011	2008 SOGHU Survey	On-going survey by SOGHU
Volume used in the different sectors (no OEM) calculated with the methodology used in the current study (for 2010)	13,971,634	23,694,966	7,577,484	4,697,062	29,793,830	17,338,702	2,287,480
Margin of error	± 2,095,186	± 6,116,286	± 1,476,502	± 648,637	± 4,198,721	± 2,802,300	± 330,625

The study does not intend to estimate precisely the volume of antifreeze sold in each province. This table provides a base for comparing volumes estimated by the provinces and the ones calculated with the methodology. It shows that the calculated volumes and the estimated volumes are similar. But since the margin of error is relatively high for the volume calculated with the methodology. That is why Dessau – NI Environnement does not recommend using these figures to calculate EHCs or any other official data.

6 RECOMMENDATIONS

DESSAU-NI Environnement suggests here a few recommendations for future studies to increase the precision of the rate of recoverable antifreeze in the 7 surveyed provinces.

Improving the precision of certain parameters

In the eventuality of a future study, it would be interesting to increase the amount of data collected in some sectors. Those such as mining, oil and gas, or construction could not be reliably referenced because of the weak response rate to the survey. The parameters from these sectors proved to contribute more to the global margin of error.

The road transportation sector influences greatly the calculations for the rate. Although there is already a large amount of data from this sector, it would be interesting to continue collecting data from road transport companies. Additional data could equally be collected from junk yards.

For the automotive sector, sampling antifreeze drained in garages may improve the precision of drained recoverable volume compared with total capacity. However, such approach might be costly and somewhat difficult to implement due to antifreeze's a lower frequency of drainage in garages when compared to motor oil.

With regards to used antifreeze, on-going measurements through the current recovery programs will allow potential calculation updates if values found were to be significantly different from the one used in this report (45%).

Updates on the number of heavy equipment in the 7 provinces would also have to be considered if any new data were identified or made available by the provinces or Statistics Canada.

Finally, during surveys, some industries that had anchored industrial equipment were contacted. Their diversity and characteristics are numerous. They consume a large quantity of antifreeze and no data exists on the number of such equipment in operation or their characteristics. In future studies, it could be interesting to gather more knowledge on anchored industrial equipment.

Review rates every five years

Developments are expected over the course of the upcoming years, such as:

- Changes to maintenance behaviour and broad dissemination of good environmental practices;
- Long-life antifreeze market share increase over the upcoming years;
- Tighter environmental regulations that could increase antifreeze capacity of vehicles;

- The appearance of radically new technologies, such as hybrid vehicles in the near future, and electric vehicles that should be adopted progressively over time, leading to modifications in the type of antifreeze consumed and their consumed-in-use rates.

In order to take these developments into account, it is recommended that segmentation of antifreeze sales and used antifreeze rates per application be reviewed every five years.