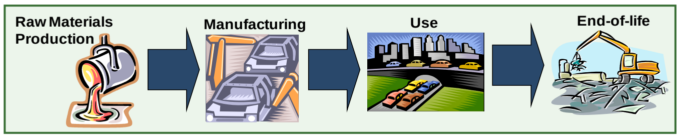
Gate-to-Gate Life Cycle Inventory Assessment of North American End-of-Life Vehicle Management Processes

Studying Vehicle End-of-Life (VEOL) Using Life Cycle Assessment (LCA)

Introduction

Definition of Life Cycle Assessment (LCA)

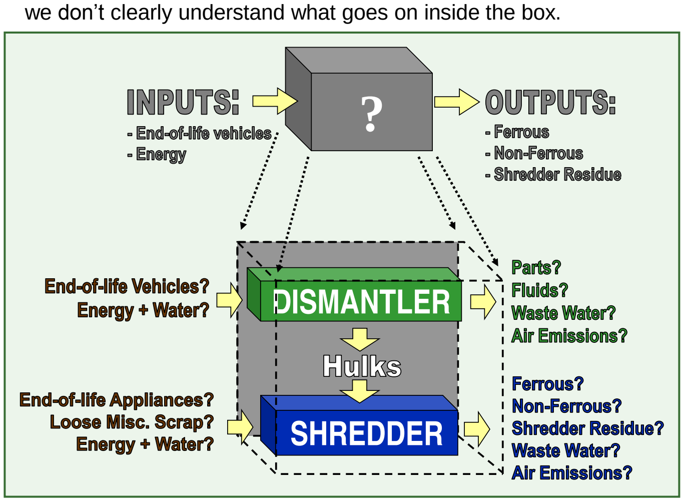
- Common definition:
  - 'Cradle-to-grave' analysis of the impacts, - materials use, energy use, and environmental impacts - of a product or process during its entire life cycle, as illustrated below:



- Additional definition:
  - 'Gate-to-gate' LCA: analysis of a process, from the gate through which the materials enter the process to the gate where the products leave

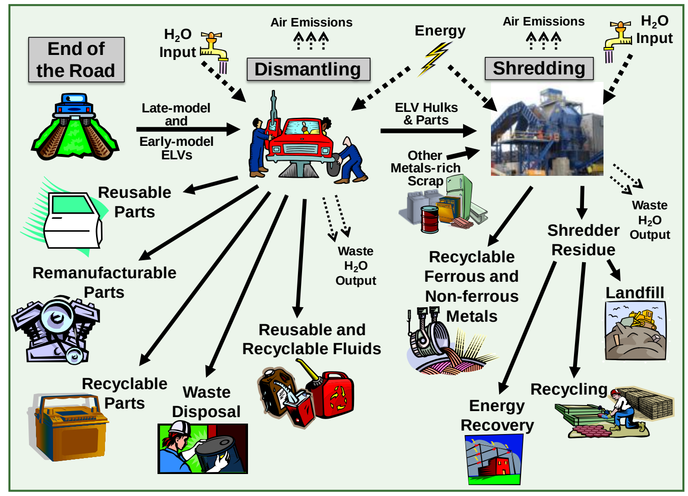
LCA Applied to VEOL

- End-of-life is the least studied phase of the vehicle life-cycle.
- Dismantling and shredding are the principal processes used for VEOL management in Canada and the U.S., with dismantling typically preceding shredding.
- There has been no exhaustive assessment of the VEOL "black box" system. Some of the inputs and outputs may be known, but not all, and we don't clearly understand what goes on inside the box.



- At the University of Windsor we are using LCA methods to study and quantify the efficiencies of dismantling and shredding systems in terms of parts and materials recovery, particularly during dismantling.
- By constructing a gate-to-gate life cycle inventory (LCI), the necessary first step of conducting an LCA of the ELV dismantling and shredding processes, we are assessing the rates that parts and materials are recovered and processed, via dismantling and shredding, on a mass basis (e.g., kilograms per tonne ELVs processed):
  1) dismantled ELV parts and materials recovered for reuse, remanufacturing, and "pre-shredder" recycling;
  2) ELV hulks and parts leftover from dismantling that are directed for shredding;
  3) ferrous and non-ferrous metals recovered by shredding and directed for recycling;
  4) the shredded leftover principally non-metallic materials, collectively referred to as shredder residue (SR), which is typically disposed of by landfilling.

End-of-Life Vehicle (ELV) Recycling Process

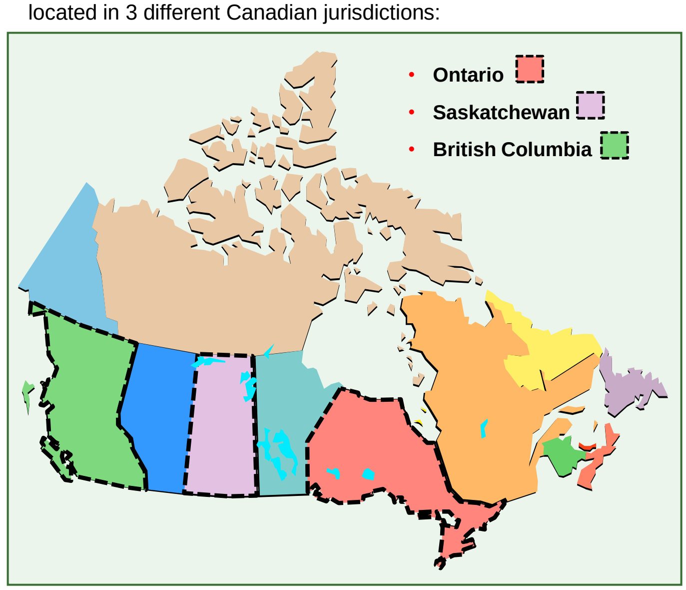


- A thorough LCA of these VEOL processes should yield valuable insights into the consequences of the current recovery infrastructure and what alternatives could be implemented to increase the effectiveness of dismantling and shredding as an overall process.

Research Approach

Case Studies

- As a result of efforts with representatives from industry trade associations, such as the Automotive Recyclers of Canada (ARC) and Canadian Association of Recycling Industries (CARI), case studies were conducted at eight facilities, 7 dismantlers and 1 shredder, located in 3 different Canadian jurisdictions:



- The case studies of the eight facilities permitted:
  1) identification and understanding of the facilities' practices and unit operations,
  2) development of process flow diagrams, showing system inputs and outputs, and
  3) collection of data for development of the LCI.

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- Data contributed by the participating industrial partners generally consisted of the quantities of ELVs, parts and/or materials entering and leaving the facilities over a typical one-year operating period, as well as electrical energy usage, water consumption and air emissions from emission control equipment.

Parts Mass Study

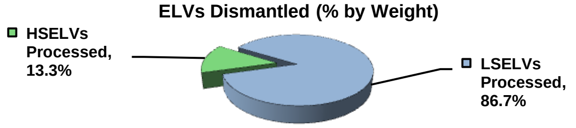
- The parts quantities supplied by the dismantlers were principally unit-based part quantities, i.e. part counts for the parts recovered and directed for reuse, remanufacturing and "pre-shredder" recycling. To be able to translate the parts counts into the mass flows required for the LCI, an industry-sponsored Parts Mass Study was undertaken to compile part weight data, as well as material compositions, for ELV components and configurations as recovered by dismantlers in the industry.
- Parts were collected by experienced dismantler mechanics, using a variety of conventional recovery techniques and tools.

- Part weight and material composition data was collected for 852 different parts, representing 307 part types collected from 49 vehicles of known make, model and model year. These part types represent parts typically recovered by dismantlers in the industry. The parts weights were applied to the dismantled part counts to establish the mass flows of parts recovered and directed for reuse, remanufacturing and "pre-shredder" recycling. The material compositions (assessed as metals and non-metals) will be used to expand the LCI and evaluate the VEOL processes with respect to materials reuse and recycling.

Selected Outcomes from Case Studies

- ELVs entering the dismantling process generally fall into one of two categories, "low-salvage" ELVs (LSELVs) or "high-salvage ELVs (HSELVs), representing 87% and 13% of the ELVs processed by weight, respectively.

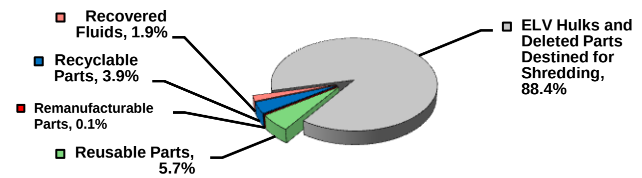
ELVs Dismantled (% by Weight)



LSELVs	– Principally "early-model", old-age vehicles, retired as a result of poor mechanical and/or physical condition or as a consequence of age and/or damage (by collision, impact, fire, or flood). – May be late-model vehicles that are so severely damaged by collision or impact that there are little or no recoverable parts for reuse. – Processed for fluids and hazardous materials recovery and **minimum** parts recovery.
HSELVs	– Principally "late-model" vehicles, retired as a consequence of limited damage by collision or impact. – Processed for fluids and hazardous materials recovery and **maximum** parts recovery.

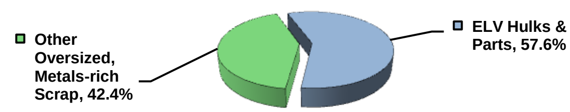
- As much as 11.6% by weight of the ELVs entering the dismantling process are recovered and directed for either, reuse, remanufacturing or recycling, including the recovered fluids. Parts recovery for reuse includes parts from both LSELVs and HSELVs: 0.8% weight and 4.9% weight of the ELVs processed, respectively.

Dismantling Recoveries (% Weight of ELVs Processed)



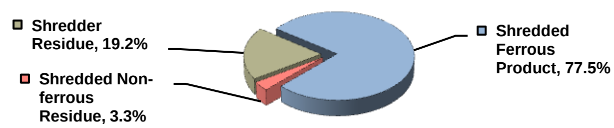
- Leftover ELV hulks and "scrapped-out" parts represent 57.6% weight of the materials processed by the shredding facility. The balance of the shredder feed materials consisted of other oversized, metals-rich scrap, such as demolition and construction scrap.

Shredder Feed Materials (% by Weight)



- As much as 80.8% weight of the shredder feed materials are recovered in the shredded ferrous and non-ferrous metal products and the balance, 19.2% weight, is accounted for in the shredder residue.

Shredded Outputs (% Weight of Shredder Infeed)



- Follow-up research includes:
  1) Assess material recoveries and losses as a consequence of ELV dismantling and shredding, and
  2) Benchmark North American ELV management system and recycling rates against legislated ELV management practices and recycling rates used in other countries (e.g., EU ELV Directive 2000/53/EC or Japan's 2002 ELV Recycling Law).
- Benchmarking North American ELV recycling rates will help policy makers to understand, for the first time, how effective the existing market-driven ELV management system in North America would be to meet ELV recycling targets without legislation.

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