GROUP PROJECT PROPOSAL

Team

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Sangwon Suh | David Raney
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Abstract

Historically, automobile manufacturers have given recyclability a lower priority than other design considerations, such as safety and fuel economy. In an effort to improve the fuel efficiency of automobiles, manufacturers have increased the use of lightweight materials, including non-ferrous metals, polymers, and composites. These factors have contributed to uncertainty about the future composition of the automotive waste stream generated by the recycling industry. Our goal is to analyze the automotive waste stream and to project its composition over the next 15 years. In addition, we will generate predictions of how the waste stream will change under different Design for Recycling (DfR) scenarios.

Executive Summary

The waste stream generated by end-of-life vehicle (ELV) management systems represents a significant portion of the municipal waste generated in the US. Materials that cannot be economically extracted from the ELV end up as automobile shredder residue (ASR), a fluff-like material that is disposed of in landfills. ASR is leftover scrap with limited salvageable value that is a byproduct of the automobile recycling process. It is composed of heterogeneous waste material including plastics, carpet, and glass (Tonn, Schexnayder, Peretz, Das, & Waidley, 2003).

As a global leader in metals recycling, Sims Metal Management handles and processes a large number of ELVs at its many US facilities. After receiving waste materials from the automobile market, Sims combines and processes these materials, recovering the recyclable materials and disposing of the remaining ASR.

The materials and design practices used during the manufacturing process have an impact on the quantity and composition of the automotive waste. We intend to evaluate the changing composition of ELVs and end-of-life automobile shredder residue. Our objective is to create a projective model of vehicle scrap composition. Such a model will inform the recycling industry’s expectations of future waste streams and corresponding management practices. In addition, it will establish a platform we can use to evaluate the waste reduction effectiveness of design for recycling scenarios.

Objectives

The objective of this project is to inform stakeholders about the changing content of the automotive waste stream by creating a model predicting the characteristics of that waste stream over the next 15 years. The model will use information provided by the auto industry, dismantlers, and recyclers to estimate the material composition of waste generated by the recycling of ELVs, including the quantity and composition of ASR. More specifically, the goals are:
I. Create a model that incorporates vehicle material composition, vehicle lifetime distribution, dismantling rates, and recyclable content to project the ELV waste stream into the future.

II. Determine the projected composition of the waste stream from the recycling of ELVs.

III. Estimate the impact DfR practices might have on the waste stream from ELVs.

Project Significance

The automobile is one of the most important products for the recycling industry. Over 95% of end-of-life vehicles enter the recycling stream in the US, and roughly 75% of the mass of each vehicle is recovered, generating approximately 12 million tons of steel and 800,000 tons of nonferrous metals for the secondary materials market (Bandivadekar, Kumar, Gunter, & Sutherland, 2004). The remaining materials end up as ASR and, in the US, are most commonly disposed of in landfills. Due to a high volume of automobiles entering the recycling stream, roughly 4.3 million tons of ASR are sent to the landfill each year, representing 3.9% of total municipal waste (Staudinger & Keoleian, 2001a).

The ELV management system is comprised of complex material and economic flows. The composition of an ELV is determined by decisions made at each stage of the vehicle lifecycle, from the manufacturing to the dismantling of the vehicle. Several factors have led to significant changes in the material composition of ELVs over the years. These changes have had an effect on the recyclability of ELVs.

The legislative push to increase the fuel efficiency of the US vehicle fleet has prompted auto manufacturers to reduce the weight of automobiles by substituting a fraction of the ferrous metals with lightweight materials such as aluminum and plastic (Das, Curlee, Rizy, & Schexnayder, 1995). While some of these lightweight materials can be economically recovered and recycled, others pose a challenge for the recycling industry and ultimately end up being disposed of as ASR.

By projecting the waste stream from ELV vehicles entering the recycling stream, we can provide the recycling industry with valuable information that would allow it to create more comprehensive ASR management strategies. Additionally, we can use our model to evaluate the effect different DfR strategies will have on the ELV waste stream. This information can be used to present a case for changes to DfR policy and design practices in the automobile industry.

Background Information

Environmental sustainability has become an issue of increasing concern to the automobile industry in recent years. To reduce the environmental impact of automobiles, many governments have passed laws that require manufacturers to collect and recycle their
products at the end of their useful life. At the same time, auto manufacturers are motivated by demand for greater fuel efficiency and safety. They are also driven to increase consumer appeal with electronics and other new features. The result is a dynamic interplay, with new materials and new design practices changing the outlook for dismantling, recycling, and the final waste stream.

In the sections below, we describe the current state of industry from several perspectives:

- The Automobile Life Cycle
- End-of-Life Vehicle Policy
- Lightweight Materials
- Hazardous Materials
- Design for Recycling
- Waste Stream Models

**The Automobile Life Cycle**

The automobile life cycle begins with the manufacturing process. Auto manufactures in the US are comprised of the Big Three domestic companies – Ford, General Motors, and Chrysler – as well as foreign manufacturers such as Toyota and Honda that operate facilities in the U.S. Manufacturers contract with a wide network of suppliers to procure parts and raw materials. Once a vehicle is sold, its lifetime is determined by consumer behavior. At the end of its useful life, an automobile is disposed of at dismantling facility. The dismantler recovers usable parts that can be resold on the secondary auto parts market and sends the remaining vehicle hulk to a recycling facility. The recycler then process the car by running it through an automobile shredder and turning it into small pieces containing ferrous metals, non-ferrous metals, and other materials. Valuable metals are recovered during the recycling process and the remaining materials are disposed of in a landfill. Currently, only metals can be recycled profitably (Westkamper, E., Feldmann, K., Reinhart, G., Seliger, 1999). Figure 1 illustrates the processes and material flows that comprise the automobile life cycle.
End-of-Life Vehicle Policy

Regulations governing vehicle production and ELV management can have a significant impact on the recycling industry. The European Union (EU) has made considerably more progress than the US at implementing policy to reduce and regulate the waste stream generated from ELVs. A major impetus for the development of ELV directives in the EU has been the shortage of landfill capacity for waste disposal, low prices in the automotive waste scrap market, and an underdeveloped used auto parts markets (Field, Ehrenfeld, Roos, & Clark, n.d.). In an effort to promote sustainable automotive design practices and reduce the waste stream from ELVs, the European Union has implemented regulations that extend producer responsibility for ELVs and seek to restrict the waste stream generated by the automobile industry.

One of the most influential pieces on legislation, the European Union’s End-of-Life Vehicles Directive, sets recycling targets for ELVs that mandate a 95% recycling rate by January 2015 (Konz, 2009). The directive enforces Extended Producer Responsibility (EPR). The purpose of EPR is to promote more sustainable design practices by extending the responsibility for the automobile’s end-of-life management to the producer. EPR has already been successful in reducing the waste generated by the EU automobile industry by promoting design practices that increase the recyclability of vehicle components and by
increasing the reuse of parts by requiring manufacturers to publish disassembly instructions (Konz, 2009). The directive also promotes the elimination of toxins such as lead and mercury from vehicle production, and mandates improvements to ELV management practices such as dismantling and disposal of ASR (Giannouli et al., 2007).

The ELV Directive is not the only piece of legislation governing the management of ELVs in the EU. Other important directives have an impact on the manufacturing and disposal of automobiles. These include the Waste Electrical and Electronic Equipment (WEEE) Directive, which applies to electronic components in automobiles, the Directive on the Restriction of the Use of Certain Hazardous Substances (RoHS), and REACH regulations that control the disposal of select chemical substances. The EU has also implemented a Landfill Directive that restricts the composition of landfill waste (Konz, 2009).

To date, there is no federal law governing extended producer responsibility for ELVs in the United States and no directives to reduce the waste stream from ELVs in the US. Attempts to pass national policy similar to the EU ELV Directive in the 1990s – policy that would enforce producer responsibility – failed due to strong industry opposition (Konz, 2009). As a consequence, producer responsibility projects in the US exist as voluntary “product stewardship” initiatives. However, automakers in the US are closely following the policy developments in the EU since they will need to comply with EPR policies for vehicles sold in the EU (Sutherland et al., 2004). Additionally, legislation has been proposed in the US that could significantly impact ELV management practices. For example, the proposed Waste-to-Energy Technology Act of 2011 would offer a tax credit for operations that utilize waste for energy generation, providing automobile recyclers with an incentive to develop methods of generating energy from ASR incineration (H.R. 66, 2011).

Lightweight Materials

In an effort to reduce dependence on fossil fuels, Corporate Average Fuel Economy Standards (CAFE) have been instituted in the US since the 1970s. CAFE standards mandate a reduction in the miles per gallon (MPG) rating for a manufacturer’s automobile fleet. Due to these mandates, fuel efficiency has become the primary driver of automobile design. Weight is the most significant factor influencing fuel efficiency. It is estimated that a 10% reduction on vehicle weight decreases its fuel consumption by 5-7% (S. To et al., 2010). As a result, there is a strong trend toward the use of lighter materials in cars; this practice is called “lightweighting”. As a practical matter, lightweighting involves the replacement of steel with alternative materials. As we look into the future, it is clear that this process will account for most of the change in the automotive waste stream as measured by mass.

Automobile designers often have to consider a variety of tradeoffs in the design and development phase of the automobile life cycle. Although fuel efficiency is a primary goal in automobile design, it is balanced against a long list of competing goals: safety, size,
maintainability, performance, installability, manufacturability, disassembly, material cost, material availability, appearance, customer perception, reusability, and recyclability (Davoodi et al., 2012).

The conflict between weight and safety is most significant. Traditionally, the quantity of steel used in a car body is chosen to make the car stiff enough to withstand a collision. In the absence of new technology, weight reduction could come only at the cost of reduced safety. However, technology has advanced quickly, introducing new design techniques and new materials which give manufacturers the opportunity to achieve both safety improvements and weight reduction (Jambor & Matthias, 1998).

Lightweight materials tend to fall into three categories:

1. Plastics
2. Non-ferrous metals
3. Composites

Fibre-reinforced plastics cannot replace steel, but they can supplement it in ways that reduce the overall weight of the car body. Designs that use plastics for lightweighting, therefore, tend to be mixed-material designs. Unless the materials are combined in a way that makes disassembly easy, mixed-materials tend to be difficult to recycle (Tempelman, 2011).

Non-ferrous metals include all metals used as a substitute for steel, but primarily refer to aluminum and, to a prospective degree, magnesium. Aluminum is capable of producing stronger structures than steel at less weight. An aluminum car body can be 40% lighter than a steel car body with the same rigidity. Aluminum has various advantages and disadvantages for the manufacturer. The limiting disadvantage is cost. Furthermore, aluminum is harder to recycle than steel because it is not magnetic and is more sensitive to the impurities it accumulates during the end-of-life process (Carle & U, 1999).

Magnesium is rarely used in significant quantities in automobiles, but it is recognized as a superior structural material than aluminum, and may be used for the engine block and body. Magnesium will probably become more common in the future (Tharumarajah & Koltun, 2007). There is little information about magnesium’s recyclability when used in automobiles.

Likewise, composites are rarely used today, but show promise for the future. Carbon fibers (also known as “sheet moulding compounds”) are extremely strong and light. Unfortunately, they are difficult to manufacture. Composites currently have no recycling potential. However, they may be incinerated, with energy recovered during the incineration.

A number of papers have attempted to quantify the lifecycle implications of automobile lightweighting. Tempelman considered lifecycle energy and lifecycle waste for four
scenarios: 1) the traditional steel construction; 2) a multi-material construction; 3) an all-aluminum construction; and 4) an all-composite construction. He found that multi-material construction and all-aluminum construction generate far more waste than the traditional steel construction. Composites are very interesting. If they can be incinerated, composites are the best option. If they cannot be incinerated, they are the worst (Tempelman, 2011).

Hazardous Materials

Hazardous materials have appeared in automobiles for a variety of reasons including convenience, function, and economics. In the U.S., certain exemptions are granted for hazardous materials including lead, which is found in batteries (recycled) and brake linings (removed during disassembly). Due to lead's toxicity when it enters the waste stream, U.S. car manufacturers have phased out application of lead soldering in car components. In 2009, the United States Council for Automotive Research LLC, (USCAR) began a process to assist car manufacturers with removing lead-based solder from electrical components. According to USCAR, this program led to a phasing out of lead soldering in audio components, instrument clusters, engine controls and other electronic components in vehicles manufactured by Chrysler, Ford and General Motors (USCAR Report, 2009).

US car manufacturers have removed mercury switches from their new automobile lines as a result of increased regulation over the past several years. Prior to 2002, automobile manufacturers had placed mercury switches in vehicles for convenient lighting in the hood and trunk and in anti-lock brake systems. In 2006, the EPA released a memorandum of understanding to establish a National Vehicle Mercury Switch Recovery Program in an effort to significantly reduce the release of mercury into the waste stream from older cars. In 2007, the EPA began regulating the manufacturing of mercury switches under the Toxic Substances Control Act and mandated the manufacturers who are producing mercury switches must notify the agency 90 days prior and be subjected to a review (USEPA, 2007).

Much of the projected increase in hazardous waste production from vehicles comes from the increased use of plastics. Plastics are the fastest growing component in shredder residue and they can be comprised of many chemical types. Plastics containing PVCs (polyvinyl chlorides) and Brominated Flame Retardants (BFRs) have come under recent scrutiny. In the past, the toxic release inventory (TRI) has not been clear about which plastics contribute to which emissions. Furthermore, TRI data on plastic type and disposal is limited (Tonn et al., 2003). The PGNV study found that the selection of specific plastics can have a significant impact on the quantity of hazardous waste associated with automobiles. Plastics may contain PVCs, BFRs, (including PBDEs, HBCDs, and TBBPAs) but are being replaced alternatives by some auto manufacturers in recent years (Ecology Center, 2012). Improved Design for Recycling can increase the utilization of automobile components on the secondary auto parts market can reduce the risk of these materials entering the waste stream.
Design for Recycling

Over time, an awareness has developed around practices that promote recyclability. These practices are known broadly as Design for Recycling (DfR), but may be known in specific instances as “design for disassembly”, “design for remanufacturing”, or “design for the environment.” The future properties of the automotive waste stream depend highly on the extent to which industry embraces design for recycling.

Various attempts have been made to refine design for recycling from a broad objective down to specific goals. Chrysler, Ford and General Motors have expressed DfR goals as recycling guidelines. Although different, those guidelines collectively encompass the following points:

- Reduce overall material diversity
- Reduce fastener count and diversity
- Avoid incompatible adhesives which degrade
- Use snap fits where appropriate,
- Avoid paints and laminates
- Build in planes for easy separation and access

(Coulter, Bras, Winslow, & Yester, 1996)

The Center for Sustainable Systems at the University of Michigan recommends guidelines with a similar, but notably different emphasis:

- Use recyclable materials
- Use recycled materials
- Reduce materials diversity within an assembly
- Mark parts for simple material identification
- Use compatible materials within an assembly

(Staudinger & Keoleian, 2001b)

The big three American auto manufacturers have incorporated their DfR guidelines into a two part rating system which consists of a recyclability rating and a material separation rating (Coulter et al., 1996).

As a practical matter, current design for recycling efforts are not highly successful. A study of the recyclability of instrument panels found that only 22% to 35% of the materials are profitably recyclable (Coulter et al., 1996). Some experts believe there is a large unrealized potential for profitable reuse and remanufacturing of parts and components (Westkamper,
E., Feldmann, K., Reinhart, G., Seliger, 1999). However, it is unclear how quickly industry will move to seize that potential.

There are two software tools of particular relevance to design for recycling and the automotive waste stream.

REPRO2 (REmanufacturing PROduct PROfiles) was developed to assist designers in analyzing the potential for remanufacturability of their products (Gehin, Zwolinski, & Brissaud, 2008). This tool seeks to determine situations in which it is profitable to remanufacture products. It uses 82 different criteria to characterize products, input processes, and business models. Among other factors, those criteria characterize the economic, technological, market, remanufacturing, and test environments in which the product is being developed and released. (Gehin, Zwolinski, & Brissaud, 2008). REPRO2 provides a ranking of product profiles based on the number of criteria that were validated. It should be noted that REPRO2 is tool is for assisting decision-making and not for proving product profitability.

ProdTect is a design for recycling tool that identifies “optimal recycling processes in legal and economic terms” to assess environmental impacts and other aspects of automobile marketing (Santini et al., 2010). It evaluates end-of-life product performance by integrating data on the recycling market into the software. Recyclers can use ProdTect to compare different recycling processes in regards to economic feasibility, efficiency, and practicability. The three outputs of the tool are: Recycling Rate, Recycling Cost/Profit and Optimal Disassembly Depth (Santini et al., 2010).

**Waste Stream Models**

Efforts to model the waste stream from end-of-life vehicles have been made in the European Union to determine the likelihood of meeting the ELV Directive’s goals of a 95% ELV recycling rate by 2015. The models use a lifecycle approach, taking into account the materials used in vehicle production, the rates of dismantling, the economic and social effects that determine the lifetime of a vehicle, and the recoverability of materials. These models can be adapted for the US vehicle market.

Schaik & Reuter created a comprehensive model of the time varying factors that affect the recyclability of vehicles in the European Union. Their goal was to determine if the EU’s end-of-life vehicle recycling targets can be reasonably met (Schaik & Reuter, 2004). Their model predicts the recycling rate of ELVs as a function of multiple parameters, including various design options. The model addresses design practices, material content, and the lifespan of vehicles. Detailed parameterization is presented, and several dynamic models are used to model the lifetime distribution of cars, weight distribution, material distribution, etc.
A similar EU study by Reuter et al. recognized that multiple economic and social factors determine the recovery rate of materials (Reuter et al., 2004). Technology, legislation, the economic feasibility of material recovery, and environmental impacts need to be considered as inputs into a predictive waste stream model. The authors present a detailed optimization model that is used to simulate the recovery rate of aluminum from ELV waste streams. In addition, inputs can be varied to model the recovery rate of other materials such as iron and steel.

In order to determine the possible applications for ASR, studies have been performed in the EU attempting to model ASR composition. In 2012, Passarini et al. published a study using a life cycle assessment approach to predict the effect eco design and lightweighting might have on the ASR composition through the year 2015 (Passarini, Ciacci, Santini, Vassura, & Morselli, 2012). The material mix was modeled using trends in ASR composition measurements collected from shredder facilities and extrapolating those trends through the year 2015. The study also included two hypothetical scenarios to model the ASR composition resulting from an increase in plastic and nonferrous metals for vehicle lightweighting purposes. In addition, the study modeled the change in ASR composition likely to result from the adoption of DfR practices.

Approach

The project will consist of a literature review, followed by data collection, modeling, and analysis.

Literature Review

The team will begin with a literature review exploring issues relevant to the project. Topics of particular interest include:

- Design for disassembly and the secondary parts market
- Auto shredder residue (ASR) composition research
- Hazardous materials in older vehicles
- Lightweight materials and design principles
- Case studies on automobile components and recycling modeling
- Environmental challenges facing the automotive industry
- Foreign and US policy addressing fuel efficiency, safety, and end-of-life

Data Collection

Data on the auto industry will be from multiple sources, including:

- Auto manufacturers
• Auto dismantlers
• Auto recyclers

Data requirements fall into two categories: (1) Data which characterize the auto fleet and (2) data which characterize the end-of-life fate of the fleet. To characterize the auto fleet, we will collect data describing vehicle composition, weight, and lifetime. To characterize end-of-life, we will collect data which correlates dismantlability and recyclability with specific brand models, materials, and design practices.

Using the data we collect, we will create a dynamic model of automotive waste that predicts the outcome of the end-of-life dismantling and recycling processes. In broad terms, our model resembles the following function:

End-of-Life Outcome = f(Fleet Characteristics, Design Trends, Vehicle Lifetime Distribution, End-of-Life Trends)

Some ideas (Anastasiya):
Improved DfR -> Lower dismantling cost -> more parts -> contracts with dealerships for certain parts -> post warranty used parts sales

Cost/Benefit for dealers
• Cost-loss of income due to used parts sales (can insure same margins though)
• Benefit-(customer retention)=used parts business + continued business from car sales

Cost/Benefit for customer
• Cost-Higher labor/parts cost
• Benefit-Reliable source of used parts

Cost/Benefit for dismantler
• Benefit-increased distribution

Where
• End-of-Life Outcome includes dismantling and recycling rates, and the quantity and toxicity of ASR residue.
• Fleet Characteristics includes material composition, weight, and design practices.
• Design Trends includes anticipated changes to vehicle composition, such as the removal of hazardous materials and the use of lightweight materials.
• Vehicle Lifetime distribution is a profile of vehicle life expectancy.
• End-of-Life trends includes anticipated changes to dismantling and recycling practices, including those influenced by policy.

The model’s implementation will be informed by existing models that have been created in the European Union. Although they will require significant modification, we believe we can
adapt these European models for the US automobile industry. Figure 2 illustrates the processes, flows, datasets and models that will be used to generate predictions of the ELV waste stream composition.

**Figure 2: ELV waste stream modeling system boundary**

![Image of the system boundary diagram]

**Analysis**

Our analysis will focus on items of particular interest to the various stakeholders, including manufacturers, dismantlers, recyclers, and the public at large. In particular, we will consider expected changes to the amount of material reused, recycled, and sent to landfills.

Furthermore, we intend to correlate changes in end-of-life outcomes with design decisions. For instance, we will compare the end-of-life fates of steel, aluminum, magnesium, plastics, and composite materials and the resulting impact on the waste stream generated from ELV management.

**Management Plan**

**Role definitions**

*Project Manager-Anastasiya Lazareva*
- Manage the project roadmap
• Set the meeting agenda and keep meeting notes
• Manage the group meeting calendar
• Distribute tasks among group members
• Ensure that the group has clear objectives
• Ensure that internal deadlines are met

Web Manager-Justin Lichter
• Create and manage the website
• Work with the team to ensure that all needed content is provided
• Solicit feedback from the team

Data Manager-Megan Barker
• Manage shared documents/research/ information
• Ensure that information is well organized

Financial Manager-Todd Matson
• Manage the budget
• Provide visibility to team members into the availability of funds

Internship Coordinator-Jonathan Chang
• Communicate with the client and Bren staff about possible internship opportunities

Meeting structure
• Weekly meetings with group members
• Weekly meeting with faculty advisor
• Monthly conference call with client
• Ad hoc meetings with external advisor and industry representatives
• PM is responsible for maintaining agenda and recording minutes

System to ensure deadlines are met
• Shared calendar (Google)
• Action Items assigned after every meeting (Asana)
• Research (Mendeley)

Conflict resolution
• Ensure clear communication
• Ensure clear and explicit expectations
• In case of conflicts, resolve as a group first and meet with advisor for direction if necessary

Information management
• All related document are shared in a Google doc folder
• Research materials are shared in Dropbox/Mendeley


• Contact information is shared in a Google doc
• Action items and deadlines are shared in Asana

**Guidelines for interacting with advisors, clients, and industry consultants**
- Monthly status reports are provided to the client during a periodic conference call
- Weekly status report (Completed tasks/plan for next week/blockers) will be sent out to team members by the PM
- All team members must be copied on all GP-related communication to the advisor/client

**Expectations of group members and advisors**
- The advisor will provide feedback on the direction of the project, the deliverables and the grading criteria.
- The advisor will communicate expectations.
- Group members will comply with internal deadlines and role responsibilities.

**Deliverables**

This project will analyze the life cycle of the US auto industry’s existing passenger vehicle fleet, from design through use, dismantling, and recycling. A dynamic model will be developed to provide information on the material composition of the waste stream from recycling operations. This information will inform ELV managers of the changes they can expect in the next 15 years. The model will highlight key metrics such as lightweight plastics. In addition, the model will be used to project the waste stream generated from ELVs if Design for Recycling practices are implemented.

**Milestones**

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<tr>
<td>Final proposal submission</td>
<td>June 7</td>
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<td>Proposal review meeting</td>
<td>June 7-15</td>
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<td>Preliminary research and data collection</td>
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<td>Data collection and analysis</td>
<td>October 15</td>
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<tr>
<td>Identify model</td>
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<td>Progress review</td>
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In order to gain a well-rounded and comprehensive understanding of the end-of-life automobile recycling and the factors that drive it, the Design for Recycling team has established contacts with professionals from a number of fields related to our target industries. Our external advisors come from professional areas including life cycle assessment, ecotoxicology, mechanical engineering, automobile dismantling and recycling, automobile design and manufacturing, and policy.

Our client, Sims Metal Management, is the nation’s largest automobile recycling company, and has access to data from its numerous facilities in varying states that will allow for comparison of recycling practices with respect to state legislation. This is particularly important given the lack of federal regulation on automobile shredder residue.

Our academic advisor, Sangwon Suh, is a pioneer in the field of life cycle assessment, and has created many models and tools for evaluating cost-effective and practical application for a variety of material usage subjects. Professor Suh will be overseeing the general direction of our project, and will provide guidance on the design of our materials evaluation tool.

Our second faculty advisor, David Raney of Raney Associates, is a former Senior Environmental Manager at Honda Motor Company with experience leading DfR initiatives. Professor Raney will consult on topics related to mechanical engineering, automotive design, and automobile manufacturing.

Our external reviewer, Herb Lieberman of LKQ Corporation, has over 50 years of experience working in the automobile dismantling industry. Because of the competitive
nature between the dismantling and recycling industries, it is imperative that we gain a balance in perspective and driving forces in all industries.

Budget

A. Expenditures

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<td>Other</td>
<td></td>
<td>$600.00</td>
</tr>
</tbody>
</table>

$1,500

B. Justification

The Bren School has allocated $1,500 for this project, of which $200 is earmarked for printing. We anticipate that the project will require one field trip to a recycling facility in Los Angeles and a second field trip to Los Angeles or another Southern California location. In addition, we have budgeted for the poster production and printing costs associated with the final presentation. Beyond these anticipated expenses, it is likely that the project will also include additional unanticipated expenses. We expect to cover these with our remaining allocation of $600.
References


