## Baseline Vehicle Material Composition

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastics</td>
<td>224.5</td>
</tr>
<tr>
<td>Aluminum</td>
<td>155.5</td>
</tr>
<tr>
<td>Copper</td>
<td>49.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>20.0</td>
</tr>
<tr>
<td>Lead</td>
<td>----</td>
</tr>
<tr>
<td>Other Ferrous</td>
<td>68.5</td>
</tr>
<tr>
<td>Iron</td>
<td>459.0</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>1387.0</td>
</tr>
<tr>
<td>HSS</td>
<td>234.0</td>
</tr>
<tr>
<td>Stainless</td>
<td>31.0</td>
</tr>
<tr>
<td>Glass</td>
<td>85.0</td>
</tr>
<tr>
<td>Rubber</td>
<td>134.5</td>
</tr>
<tr>
<td>Fluids</td>
<td>179.5</td>
</tr>
<tr>
<td>Other</td>
<td>83.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3111.0</strong></td>
</tr>
</tbody>
</table>

- **Ferrous**: Iron, Carbon Steel, HSS, Stainless
- **Nonferrous**: Aluminum, Copper, Zinc, Other Ferrous
- **Unrecyclable**: Plastics, Rubber, Fluids, Other

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"First Principles" Mass/MPG Calculation

MPG = 8627.4 (Mass) -0.74584

Vehicle Mass (pounds)

Mile Per Gallon
Rule Of Thumb - 10-5 Rule

- A 10% Reduction In Mass...
- Yields A 5% Increase In Fuel Economy
- So, If A Baseline 3111 lb Vehicle Gets 21.6 mpg...

\[ \text{MPG} = 895.24 \times (\text{mass})^{-0.463} \]
Some Scaling Modifications:

$$Mass = 2.015 \times FE^2 - 194.85 \times FE + 6375.54$$
Estimated Costs of Recycling Processing

- **Assumptions:**
  - Cost of Hulk - approx. $50
  - 70 ton/hr shredder
  - 8 hrs/day operation
  - 4 hrs/day maintenance
  - Transportation Costs - $0.10/ton/mi

- **Regression: Cost / Vehicle**

  \[
  \text{Cost} = -48.7820 - 0.0153 \, F - 0.0079 \, N - 0.0072 \, U
  \]

- **Where:**
  - \( F \) = Car Ferrous Mass (lbs)
  - \( N \) = Car Non-Ferrous Mass (lb)
    (not including lead)
  - \( U \) = Car Unrecyclable Mass (lb)
Rules of Thumb For Revenue & Landfill Expenses

- Cost of Landfill --- $120/ton
- Value of Ferrous Scrap --- $100/ton
- Value of Mixed Nonferrous Scrap --- $900/ton
- Separation Efficiencies --- 90% of ferrous recovered
  90% of nonferrous recovered
  rest goes to landfill

- Dismantlers Get Some Off Before The Shredder:
  50% of the Iron
  80% of the Stainless
  50% of the Aluminum
  25% of the Copper
  50% of the Glass
  50% of the Rubber

- This is a function of the kinds of parts made of these materials.

- For the purposes of this analysis, use the regressions to calculate the costs of the baseline vehicle. Then use the top 4 bullet facts to look at the impact of changes in the vehicle material composition.
Ferrous Metal Revenue - Estimated

- Assumed
  - $100/ton shredded steel scrap
  - Standard Processing

- Regression Results From Cost Model

- Where (all in pounds):
  - \( F \) = total ferrous mass of car
  - \( N \) = total nonferrous mass (net of battery lead)
  - \( U \) = total mass of unrecyclable

- Result:-in dollars per vehicle

\[
2.2248 + 0.0376 F + 0.0055 N - 0.0068 U = \text{Ferrous Revenue}
\]
Non-Ferrous Metal Revenues - Estimated

- More Detailed Estimate
- Recovery Rates of Aluminum, Copper, and Zinc Different
- Overall Mixed Metal Scrap Value Assumed At $0.45/lb

Result-Dollars per vehicle:

\[
\text{Revenue} = 0.2025 \text{ Al} + 0.3038 \text{ Cu} + 0.4050 \text{ Zn}
\]

Where:
- Al = total aluminum in car
- Cu = total copper in car
- Zn = total zinc in car

Note: Aluminum companies are being pressed to offer higher scrap values!
Landfill Cost Estimate

- Assumptions:
  - Landfill Cost - $120/ton
  - Separations Not 100% Efficient

- Results: Landfill Cost Per Vehicle

\[
\text{Cost} = 6.9382 - 0.0018 \ F + 0.0041 \ N - 0.0574 \ U
\]

- Where:
  - \( F \) = Car Ferrous Mass (lbs)
  - \( N \) = Car Non-Ferrous Mass (lb) (not including lead)
  - \( U \) = Car Unrecyclable Mass (lb)