Modeling Vehicle End-Of-Life

Studying the Effects of Materials Substitution on the Automobile Recycling Infrastructure

TPP 123

Auto Recycling Overview

- Major Steps
  - Dismantler
  - Shredder
  - Nonferrous Separator
  - Landfill (Hopefully, ASR Processing)
Key Events Leading to the Modern Recycling System

- Initial reduction in scrap use
  - Decline of open hearth
    - BOF uses little to no scrap
  - Increasing labor rates
  - Tightening enviro regs
- Increase in scrap consumption
  - Auto shredder
    - Less labor
    - “Cleaner” scrap
  - Electric arc furnace
    - Uses up to 100% scrap

Why Care About Automobile Recycling

- Autos are significant consumers of resources
  - Aluminum: 19%
  - Lead: 70%
  - Platinum: 41%
  - Rubber: >60%
  - Iron: 35%
  - Steel: 14%
The Auto Recycling Infrastructure is Efficient

- **Vehicle reclamation rates**
  > 90%

- **Material recovery rate**
  > 75%

- **In US, recovers:**
  - Steel -- 13 M tons
  - Nonferous -- 0.8 M tons
  - Rubber -- 1.6 M tons

- **Compare to:**
  - Total recycling industry ~100 M tons
  - Total MSW ~ 200 M tons

How Does Auto Recycling Compare?

- **Other, more familiar systems are far less efficient**

- **From municipal wastes**
  - Al Cans ~60%
  - Paper ~40%
  - Glass ~25%
  - Plastic ~10%
  - Total MSW ~27% *incl. composting*

- **All of these reclamation systems are partially subsidized**
Why Does the System Work So Well?

- System is propelled solely by profitability of each business
  - NOT by government policy intervention
- Revenues from
  - Reusable parts
  - Materials

Average Revenue Streams

- Resalable parts
  - Alternators, engine blocks, radiators, catalytic converters ....
  - Dismantlers receive on average $170 / cars for parts
- Materials value to shredder
  - Ferrous materials -- $90 / car
  - Nonferrous -- $50 / car
  - ASR disposal -- $12 / car (cost)
- Nonferrous processor
  - Scrap value -- $100 / car
System Conditions are Changing

- How will the auto recycling system respond to changes in:
  - Vehicle composition
    - 500 lbs of ferrous materials removed since late 70s
  - Regulatory requirements

![Graph showing vehicle content from 1977 to 2000 with different materials represented]

Overview: Latest Version of EU Recycling Legislation

- By 2006,
  - Re-use/recycle 80% of vehicles by weight
  - Re-use/recover 85% of vehicles by weight
  - Design for 85% recyclability and 95% recoverability
- By 2015
  - Re-use/recycle 85% of vehicles by weight
  - Re-use/recover 95% of vehicles by weight
  - Automakers are to integrate as much recycled material into car as possible
Overview: Policy Summary

- It should not cost last holder/owner to deliver vehicle to treatment facility
- Presentation of certificate of destruction is condition for deregistration
- Producers should meet all or significant part of costs for implementing measures for delivery of vehicles
- Recyclers must become authorized facilities
- Target recycling goals
Introduction & Problem

- Vehicle Recyclability As A New Challenge To Vehicle Production & Design
- Issue Has Stimulated World-Wide Reaction
- What Is The Problem?
- What Should Be Done About It?
- How Should This Set Of Actions Be Implemented?

Vehicle Recycling

- Emerging Environmental Policy
  - German Waste Management Law Initiated Current Push
  - Shredder Concerns Regarding Polymer Content and ASR Disposal Costs
  - EC Also Pursuing Aggressively

- Political Motivation
  - Polluter Pays Principle
  - Extended Producer Responsibility
  - Abandoned or Improperly Disposed-Of Vehicles

- Objectives Introduce New Interplay Between Vehicle Performance, Economics, and Market Goals
Vehicle Recycling

- Well-Established Vehicle Recycling Infrastructure
- Economics Of Infrastructure Dominated By Shredder Economics
- What About Changes In:
  - Materials Content
  - Landfill Availability/Cost

Changing Automobile Materials Content

Pounds/average vehicle

Year

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German Initiative - Driver Of Vehicle Recycling Issue

- Motivate Last User To Put Vehicle Into Reprocessing Stream
  - Certificate of Deposit
- Create Incentive For Recycling
  - Increase Landfilling Costs
  - Improve Dismantler Infrastructure
  - Increase Costs Of Disposing Of Incinerator Ash
- Require Automakers To Be Responsible For Product Disposition
  - Producer Take-Back

Issues With The German Initiative

- Crucial Markets and Actors Not Directly Included
  - Secondary Metal Markets
  - Shredders
  - Secondary Metals Processors
  - Used/Reconditioned Parts
- Shredders Especially Critical - Central Processing Element
Baseline Shredder Economics

1980 Model Year

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<td>Other Variable Costs</td>
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<td>NET</td>
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Shredder Economics - As Tipping Fees Increase

$20/Ton Tipping Fee

Vehicle Model Year

$100

$200

$0

($100)

($200)

$200/Ton Tipping Fees

Vehicle Model Year

$100

$200

$0

($100)

($200)
Certain Material Changes Implicated In Recycling Problems

- Increasing Polymeric Materials Content
  - Supplanting Metals - Revenues Decrease
  - With Essentially Valueless Material - Disposal Costs Increase

- Increasing Non-Ferrous Materials Content
  - More Valuable Than Ferrous Content At Present
  - As Amount And Diversity Of Material Types Increases, May Not Be As Valuable

- Decreasing Ferrous Materials Content
Shredder Economics - Versus Vehicle Material Content

US Average Vehicle Material Content

Pounds/Car

0 1,000 2,000 3,000 4,000


US Shredder Economics

$20/Ton Tipping Fee

$/ton Ferrous Scrap

$100 $150 $200 $250 $300 ($100) ($150) ($200) ($250) $300 $150 $100 $0

Vehicle Model Year

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Shredder Profit vs. Increasing Polymer Content

$70 $60 $50 $40 $30 $20 $10 $0

$20/ton

Increasing Tipping Fees

$100/ton

$ per ton recovered ferrous scrap

$ per ton recovered ferrous scrap

Ferrous Scrap Price: $100/ton
Nonferrous Scrap Price: $900/ton

Amount of Polymers per Vehicle (lbs)

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Extended Reprocessing Stream

**ASR Pyrolysis Cost Breakdown**

<table>
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<tr>
<th>Item</th>
<th>Cost</th>
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<tr>
<td>Labor Cost</td>
<td>($40.00)</td>
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<tr>
<td>Energy Cost</td>
<td>($8.00)</td>
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<tr>
<td>Equipment Cost</td>
<td>($58.59)</td>
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<tr>
<td>Fixed Overhead Cost</td>
<td>($31.46)</td>
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<tr>
<td>Building Cost</td>
<td>($13.56)</td>
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<td>Maintenance Cost</td>
<td>($17.73)</td>
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<tr>
<td>Landfill Cost</td>
<td>($15.30)</td>
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<td>Oil Revenue</td>
<td>$19.98</td>
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<td>NET LOSS</td>
<td>($164.66)</td>
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**Economics of Shredding, With & Without Pyrolysis**

<table>
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<tr>
<th>$/ton recovered ferrous scrap</th>
<th>Landfill</th>
<th>All Other</th>
<th>Revenue</th>
<th>NET PROFIT</th>
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<td>Shredder/Landfill Route</td>
<td>($7.41)</td>
<td>($78.71)</td>
<td>$148.04</td>
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<td>Shredder/Pyrolysis/Landfill Route</td>
<td>($3.77)</td>
<td>($141.37)</td>
<td>$155.43</td>
<td>$10.29</td>
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**Issues In The Expansion Of Recycling**

- **Technological**
  - Separation Is Difficult & Expensive
  - Separation Is Key To (Re)Processing Efficiency and Product Quality
  - Ferrous, Nonferrous, and Polymeric Materials *ALL* Subject To These Limitations

- **Economic**
  - Primary Materials Markets
    - *Focus Upon Purity/Quality Of Material*
  - Secondary Markets
    - *Balance Costs Of Purification Against Market Demand*
    - *Ceiling On Price - Virgin Material Or Ores/Feedstocks*
  - Markets Reflect Tension Between Product Value & Separation Expenses

- **Political**
  - Unacceptability Of Disposal & Thermal Recovery
  - Unwillingness To Levy Fees On (Last) Vehicle User
Shredder's Role In Recycling Infrastructure

- Historically, Central Motivation For Vehicle Recycling
- Economics Most Favorable Of Any Element Of The Process
- Accessing Or Redistributing This Revenue Is Difficult With Current Policy Instruments
- Unlikely That Other Instruments, Short Of Rationalizing The Entire Process, Will Serve Any Better

Consequences For Policy Development

- Conflicting Objectives
  - Landfill Use Reduction and Resource Conservation
  - Increased Costs Of Disposal & Distribution Of Costs
  - Free Market Reprocessing & Disposal
- Current Policy Strategies
  - Producer Take-Back
  - Recycled Material Content or Other Material Specifications
  - Deposit/Point-of-Sale Fees
  - Certificates of Disposal
- Limitations Of Current Policies
  - Value Of Land Resource Versus Other Resources Not Considered
  - Market Responses To Disposal Enforcement Not Understood

Recycling Alone Is Too Narrow A Policy Focus For Effective Environmental Improvement
Mistake To Focus Solely On Recycling
Other Crucial Consequences

- Materials Selection Driven By Fuel Economy Requirements
  - Weight Reduction & Frame/Body Stiffness
  - Compatibility With Existing Manufacturing Systems

  Implies That Vehicle Use/Gasoline Consumption Should Be Considered

- Material Choice Has Implications At Resource Extraction
  - Ore/Petrochemical Extraction
  - Conversion

  Implies That Resource Extraction Must Be Considered

- Material Choice Has Implications For Component Forming/Manufacturing

  Implies That Component Fabrication/Assembly Must Be Considered

- Materials & Engine Performance Improvements

  Implies That Vehicle Emissions & Controls Must Be Considered

Recycling Objectives Must Be Reconciled

- Resource Conservation -
  An Issue In Recycle, Reuse, & Disposal Of Vehicle, But Also Is Inherent In:
  - Resource Extraction
  - Material Refining
  - Vehicle Manufacturing
  - Vehicle Use

- Today's Recycling Conflicts Reflect The Question Of Where and How Companies & Markets Can Most Effectively Employ Resources

  Consider -
  Polymers Are Viewed As The Culprit Limiting Vehicle Recycling Today, But:
  - They Are Manufactured From Low Value/Energy Materials
  - They Require Less-Capital Intensive Manufacturing
  - They Reduce Vehicle Energy Consumption

  Are Polymers The Problem, Or Only An Aspect Of A Larger Question?
A Balance Of Objectives Must Be Struck

- Recycling As One Aspect Of An Overall Environmental Strategy

- Policy In This Area Must Reflect:
  - Ongoing Technological Development
  - Ongoing Market Development
  - Ongoing Infrastructure Development
  - Regional Differences

- Efforts To Manage This Development Must Concentrate On Helping To Resolve Conflicts Between One Class Of Environmental Objectives And Another

- Policies Should Avoid Defining Implementation Specifics
  - Complexities Of Managing Markets
  - Difficulties In Creating Infrastructure
  - Limits To "Technology-Forcing"